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CRUISE REPORT

R/V ENDEAVOR - CRUISE ²¹⁷~~127~~
SEPTEMBER 7, 1990 - SEPTEMBER 17, 1990
NARRAGANSETT, RHODE ISLAND TO WOODS HOLE, MASSACHUSETTS

A WIDE-ANGLE REFLECTION/REFRACTION PIGGYBACK OF THE EDGE CHESAPEAKE BAY TRANSECT

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Frontispiece

AVHRR imagery representing sea surface temperature showing the OBS and OBH locations (crosses) reaching out to the Gulf Stream off Chesapeake. (Computed and plotted on board RV ENDEAVOR by David Nelson.)

SUMMARY

This cruise report describes a cooperative project with the United States Geological Survey to use ocean bottom seismometers (OBS) and hydrophones (OBH) to record wide-angle reflection and refraction data from the large airgun array source of the seismic vessel GECO SEARCHER as it shot the EDGE Chesapeake Bay transect across the U.S. east coast continental margin. This experiment, including its coordination with University of Wyoming and University of Georgia land crews, was extremely successful. All twelve OBH and OBS instruments were recovered and useful data totalling in excess of 1 Gb were recorded on ten units. Good weather throughout simplified deployment and recovery operations. Good communications with our colleague John Collins on board GECO SEARCHER and the cooperative attitude of the GECO crew were crucial to the difficult task of coordinating the instrument deployment sequence. The operational practicality of this kind of 'piggyback' experiment, given the full cooperation and understanding of the URI ship operators, was established again. The power and effectiveness of continuous digital recording on to hard disk in ocean bottom instruments was unequivocally proven. More digital data was recorded during this one experiment than during all previous experiments using these instruments combined.

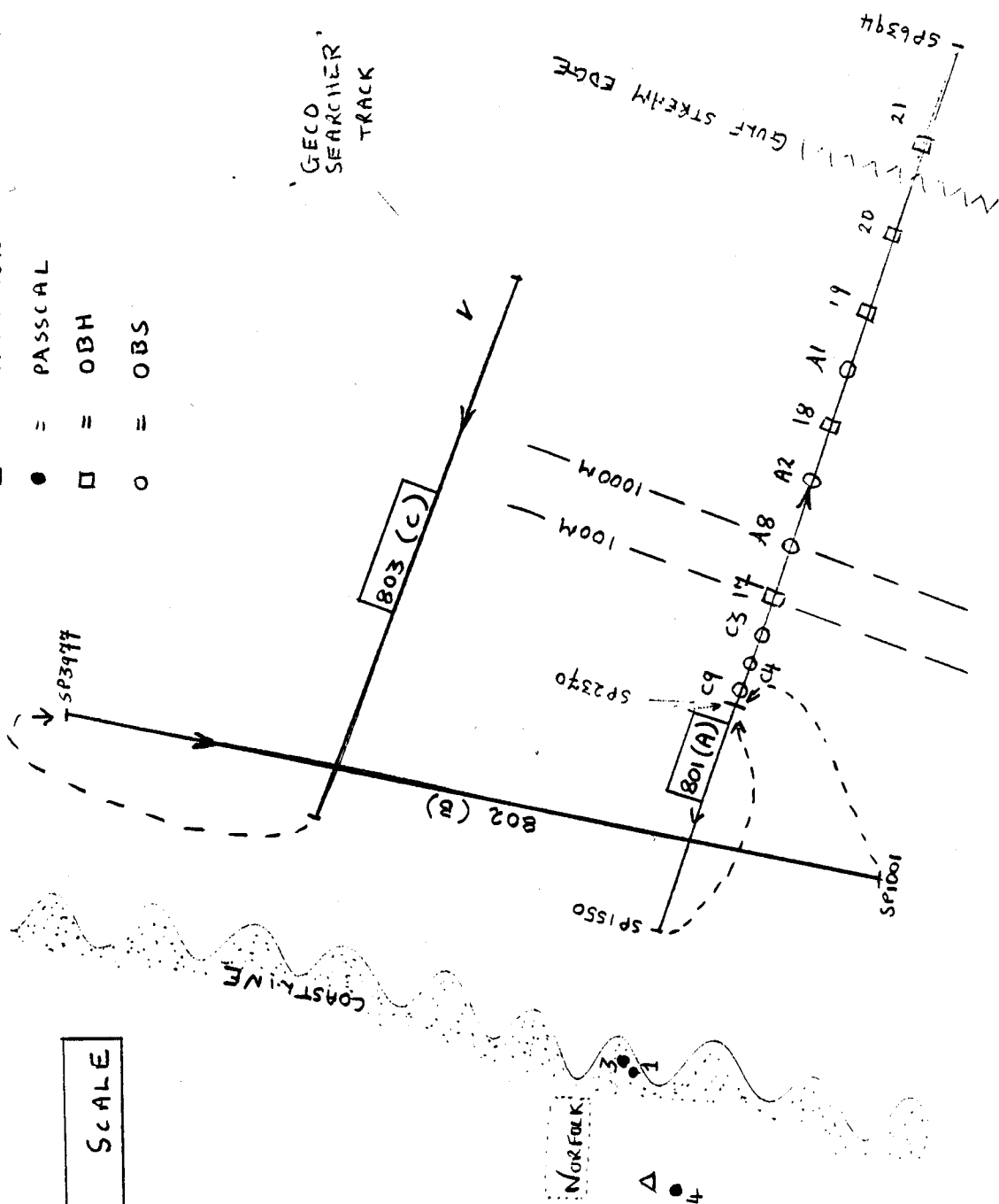
SCIENTIFIC OBJECTIVES

- Determine an accurate two-dimensional velocity structure across the complete margin province, from pure continental to normal oceanic crust.
- Image the lower crust and moho beneath the marginal sedimentary pile that is invisible to conventional multichannel seismic reflection experiments.
- Undershoot the margin carbonate bank complex and volcanoclastic wedge that thus map the underlying structures.
- Establish the geometry of the Moho across the margin.
- Determine the nature of rift stage crust.
- Characterize rifted continental crust.
- Determine the nature of marginal oceanic crust.
- Constrain models for the source of the East Coast Magnetic Anomaly.

OPERATIONAL OBJECTIVES

- Wire test sixteen new EG&G acoustic transponder/releases.
- Carry out test deployments of one OBH and one OBS to check suitability of the absolute gain settings.
- Record absolute shot times accurate to ~1 ms on board GECO SEARCHER.
- In coordination with the commercial seismic vessel GECO SEARCHER, deploy twelve ocean bottom seismic instruments along line A of the EDGE projects Chesapeake Bay transect.
- Recover all instruments after recording all GECO SEARCHER's airgun shots along this line.
- Redeploy three of these instruments to line B.
- Coordinate shooting operations with deployment of land instruments by Scott Smithson of the University of Wyoming and Bob Hawman of the University of Georgia.

Δ = HAMMON
 ● = PASSCAL
 □ = OBH
 ○ = OBS



NOT TO SCALE

CARTOON SHOWING RELATIVE
 INSTRUMENT LOCATIONS

NARRATIVE

Loading of R/V ENDEAVOR in Narragansett began on the afternoon of 5th September and continued through the 6th. All personnel being on board (Appendix 1 and 2) we sailed as scheduled (see Appendix 5) at 1600 LT on 7th September. Throughout the day of the 7th, repeated communications with GECO both in Houston and in Norfolk attempted to obtain copies of the shot point navigation and to determine the sailing schedule of GECO SEARCHER from Norfolk. Shot positions were faxed to us from GECO Houston but they were incorrect (25m instead of 50m spacing). Some concern was caused by the stated intent of SEARCHER to sail at 1300 8th when we knew John Collins, who would record shot times on the SEARCHER, would not arrive in Norfolk until 1100. On the morning of the 8th, while we steamed south to the work area with ~15-20 knot winds behind us, we contacted both the Party Chief on the SEARCHER and the land crew coordinator (Chris Humphries of the University of Wyoming) via INMARSAT. Significant questions concerning the order in which the lines would be shot remained. The land crews, however, were in good shape and began reconnoitering instrument sites.

At ~1015LT we stopped to carry out wire tests of the EG&G 8242 transponder-releases, which were completed in four lowerings on the hydro wire down to 1000m (Appendix 11), and used up most of the day. In addition we carried out a simple 'float test' of one of the large USGS spheres to check its stability on the surface.

GECO SEARCHER sailed from Norfolk on the afternoon of 8th bound for the eastern end of line 803 (see Figure). A long INMARSAT call to the SEARCHER at 7:00 p.m. that evening clarified many issues. John Collins was on board and we also spoke with Bob Sheridan. We confirmed that the shot point coordinates we had received from GECO were incorrect; we determined that SEARCHER had no LORAN set on board; the final shooting order of 803, 802 and then 801 was good for us but the understandable decision to break 801 into two sections, and shoot them in opposite directions (see Figure), introduced some instrument scheduling difficulties for us. It substantially increased the total elapsed time for the shooting of 801.

The morning of the 9th September was calm and sunny and beginning at 0815 we launched one OBH and one OBS (Appendix 3) for a test deployment. We fired a 40 cu. in. airgun at a one minute repetition rate out to a range of a few miles. Recovery of the instruments was relatively uneventful: the OBH surfaced 800m from the ship and was not immediately visible. The new Novatech VHF band radio beacon, however, gave an excellent bearing. For the OBS recovery we maintained position on the LORAN drop point and it surfaced within ~200m. Data replay showed that the OBH recorded excellent signals and indicated that ambient noise levels were comparable to those experienced during our Carolina Trough operations in 1988. The OBS recorded no hydrophone channel and one horizontal channel did not function. But the vertical and the other horizontal sensor gave good data.

We got new navigation data from the SEARCHER and steamed landward overnight to be near the intersection of 803 and 802 (see Figure 1) where we planned to drop our first instrument (OBH 16). By now we had established good radio contact with SEARCHER on either SSB or VHF, using INMARSAT to establish our first SSB contact on 4125 MHz. Our previous confusion over the non-linearity of some of the shot point locations that we had obtained from GECO along 801 was resolved when we realized that they steam great circles between line end points and we were plotting our fixes on a Mercator projection chart. At the 1630 radio schedule on 10th September with the SEARCHER we passed on the line coordinates (in kms) of our desired instrument locations along line 801. At that time they were planning to start shooting 803 at approximately 1830 (10th). But at

the 2015 schedule we learned of further delays (streamer problems), so instead of moving in to deploy OBH 16 we hove-to overnight. We received a message from the SEARCHER at 3:45 a.m. saying they had just begun shooting 803. We confirmed that good progress was continuing at a second radio call at 0615 and deployed OBH 16 at 0715LT 10th. The shot point locations, at which our instruments were to be deployed, that we received from SEARCHER were 'true' positions provided by their STARFIX navigation system. In order to correct these positions for the Loran offset (because our deployments would be made using Loran [Northstar 7000 and 800]) we wrote a simple program on the VAX to look at the previous 1-3 hours of navigation data recorded on the ship's data logging system and compute a mean difference between Loran and GPS. We repeated this operation immediately before each instrument deployment. Offsets ranged between 0.02 to 0.17 minutes.

Immediately following deployment of OBH 16 we steamed east at full speed to the oceanward end of 801. The weather continued to be excellent: 10-15 knots and a clear blue sky. The 1415 radio schedule showed SEARCHER's progress to be excellent; the predicted time for completion of 803 was 1800LT. We hit the Gulf Stream at longitude 73°36'W (see figure). Fortunately only OBH 21 will have to be deployed in these difficult 3-4 knot currents. We used a double anchor on this instrument that increased the sink rate to 129m/min. and got the instrument through the current quickly. We deployed OBH 21 0.25 nm up current of where we wanted it to land at 1645 11th. The plan was then to steam back west along the line and deploy all the OBH, which with their ~6 day continuous recording capability, could survive even substantial delays in the shooting program. The OBH 20 and 19 went smoothly, although a troublesome release had to be replaced on OBH 20 at the last minute because it became apparently locked into a 2s timed pinging mode. The 0015/11th radio scheduled showed the SEARCHER would begin shooting 802 at 0130/12th. OBH 16 and the land instruments would record all of this line.

OBH 18 was launched at 0715/12th and the 0815 radio schedule showed SEARCHER was still on schedule, so the final OBH (17) was deployed. We then steamed to the first OBS launch position and monitored SEARCHER's progress. We wanted to be as sure as possible of the time at which shooting would begin along 801 before committing to a start time for the OBS. Given their ~35hr continuous recording capacity they could only just get the whole of 801 if the start time was exactly correct and no delays were experienced.

At the 1415 schedule we learned of gun problems on the SEARCHER that would cause a ~3 hour delay. At the 1730 schedule all was well, the predicted end of 802 was 2145LT, and the beginning of 801 West was 0515/13th. Based upon these estimates we launched the first OBS (A1) at 1830/12th, OBS A2 at 1945 and OBS A8 at 2115 (see figure and Appendix 3). The remaining three shallow water OBS were held back until even more reliable estimates of the start time could be made. At 2210LT we heard that SEARCHER had finished shooting 802 and was turning north to the break point in 801 to begin shooting the western end of 801 towards the shore. In order to maximize the chances of recording all of 801 on one of the OBS, instrument C9 that was to be deployed near the break point, was held back until the SEARCHER was only ~2 hours away. C9 was launched at 0330 13th September. Visibility was near zero in dense fog at this time. GECO SEARCHER began shooting 801 West at 0650/13th. The last two OBS were to be launched just before SEARCHER began 801 East to ensure data was obtained from the easternmost shots. Line 801 West was completed near midday on the 13th.

Throughout this time good contact was maintained with Chris Humphries (University of Wyoming) who was coordinating the land operations via ATS and his cellular telephone.

We began to learn of some potential timing problems (see Appendix 6). Our True Time satellite was not tracking our rubidium standard and it repeatedly locked on to the 'West' satellite which is not supposed to be operational. We requested John Collins log the status of his True Time and we began a careful evaluation of the offsets between our various timing systems as they varied depending upon the satellite that True Time was receiving.

The last two OBS were launched on the afternoon of the 13th, C3 going over the side at 1645 just before SEARCHER began shooting 801 East at 1800. We then steamed off to the northeast to a point 15nm north of the first instrument that we planned to recover and waited for SEARCHER to complete the shooting line.

On the morning of the 14th, we determined that SEARCHER had experienced some minor delays and would finish shooting 801 East near 2100LT. At 830/14th we carried out wireline tests to check the performance of two release units with which we had concerns (Appendix 11) and to check the performance of our new deck unit. This test was completed by lunch time in the pouring rain, and we hove to all afternoon waiting for the shooting to end. We began recoveries at 1900 and extremely rapid progress was made. By 0330/15th we had five OBS on board. Recoveries were straightforward, the radios added to the large deepwater spheres proving to be extremely valuable. This Novatech VHF radio beacon along with ENDEAVOR's SIMRAD Taiyo ADF are excellent aids to recovery.

The last OBS (C9) created a real problem, however. It was in shallow water (29m) and transponded clearly and correctly but would not respond to a release command. We tried at ranges of 50 to 1200m using every deck box and transducer available but after more than an hour at 0430/15th, we gave up and steamed west to recover OBH 16. This went smoothly and by 1030/15th we were back over C9 preparing a grappling hook rig to attempt to drag the instrument off the bottom. However, the instrument accepted the first release command that was transmitted and it was immediately recovered without mishap. No immediate explanation for this is available. Recovery of the remaining OBH instruments continued, two more being on board by 1600/15th. Given the quality of Loran navigation these shallow water recoveries were trivially simple. Two more instruments (19 and 20) were recovered by 2130.

The greatest challenge was the recovery of OBH 21 which was located beneath the Gulf Stream. This began at 0630/16th. We located the instrument ~0.3nm down current of where it was deployed, and following release we held station on it and allowed ourselves to drift down-current very slightly as it rose through the water column. This involved steaming at ~3.5 knots into the current. The transducer fish, towed on the hydro wire from the J frame was essential to this operation. When ~600m beneath the surface the OBH began moving rapidly down current (we saw a change in slope on the graphic recorder) and even though we stopped the ship at that point, we 'saw' the instrument pass beneath us and move away astern. It surfaced ~200m away on the port quarter and recovery was uneventful. It was on board by 0830 16th when we set course at full speed for Woods Hole. The seas were flat calm.

We came alongside the WHOI dock at 1500 17th September.

APPENDIX 1

Science Complement

G.M. Purdy }
W.S. Holbrook} Co-Chief Scientists

K.R. Peal - WHOI
D.L. DuBois - WHOI
R. Handy - WHOI
G. Miller }
M. Martini - USGS Woods Hole
D. Nelson - URI Marine Tech.

APPENDIX 2

Crew List

Tom Tyler	-	Master
Rhett McMunn	-	Chief Mate
Tom Viti	-	Second Mate
Bill Appleton	-	Chief Engineer
Tim Varney	-	Assistant Engineer
Pup Gould	-	Assistant Engineer
Jack Buss	-	Bosun
Ed Adams	-	Able Body Seaman
Richard Chase	-	Able Body Seaman
Craig Peters	-	Chief Steward
Heidi Mindnich	-	Assistant Steward

APPENDIX 3

Inst. ID	SP #	Line Coord. (from East end of line 801 (km)	Drop Time (GMT)	Start Time (GMT)	Recovery Time (GMT)	DEPLOYMENT Latitude Longitude	Depth (m)	Nav. Quality	Comments
CHES01									
OBSA2		Test Deployment	9/9/90 1346	9/9/90 1400	9/9/90 2111	36°59.976'N 74°14.893'W	1885	GPS	185 tracks (229 written, 216 bytes of data per track). Three geophone channels worked. No hydrophone channel data.
OBFZ1		Test Deployment	9/9/90 1510	9/9/90 1530	9/9/90 2001	37°00.036'N 74°15.009'N	1878	GPS	32 tracks written - no errors.
CHES02									
OBFH6	1992	~222.3 801/802 Intersection	9/11/90 1113	9/12/90 0330	9/15/90 1315	36°44.510'N 74°23.910'W	24	LORAN	517 tracks written - Disk error at track 517. PPMA required.
OBFZ1	5774	31	9/11/90 2049	9/13/90 0300	9/16/90 1229	36°22.278'N 73°20.022'W	3291	GPS	514 tracks written - no errors.
OBFZ0	5074	66	9/12/90 0140	9/13/90 0300	9/16/90 0136	36°26.755'N 73°42.725'W	2903	GPS	445 tracks written - no errors. PPMA required.
OBFH9	4574	91	9/12/90 0325	9/13/90 0300	9/15/90 2306	36°29.700'N 73°58.981'W	2603	GPS	429 tracks written - no errors.
OBFH8	3834	128	9/12/90 1124	9/13/90 0300	9/15/90 2005	36°34.024'N 74°23.270'W	1950	GPS	411 tracks written; probably no good data; fuse to Analog (-) power supply was blown; pinched wire probably occurring during pre-deployment assembly is suspected cause. PPMA

APPENDIX 3 (cont'd.)

Inst. ID	SP #	Line Coord. (from East end of line 801 (km)	Drop Time (GMT)	Start Time (GMT)	Recovery Time (GMT)	DEPLOYMENT Latitude	Longitude	Depth (m)	Nav. Quality	Comments
OBSA1	4074	116	9/12/90 2223	9/13/90 0900	9/14/90 2351	36°32.620'N	74°15.470'W	2121	LORAN	890 good tracks; 37 error tracks. Three geophone channels worked. Hydrophone channel data intermittent.
OBSA2	3574	141	9/12/90 2348	9/13/90 0900	9/15/90 0209	36°35.590'N	74°31.793'W	1527	GPS	No data - system would not respond.
OBSA8	3374	151	9/13/90 0121	9/13/90 1700	9/15/90 0326	36°36.810'N	74°38.379'W	1050	GPS	860 good tracks; 9 error tracks. Three geophone channels worked. Hydrophone channel data intermittent.
OBSA9	2414	199	9/13/90 0730	9/13/90 0930	9/15/90 1457	36°42.318'N	75°9.989'W	29	GPS	667 good tracks; 150 error tracks. Three geophone channels worked. Hydrophone channel data intermittent.
OBSA4	2654	187	9/13/90 1904	9/13/90 2000	9/15/90 0618	36°40.952'N	75°02.030'W	30	GPS	899 good tracks; 22 error tracks. Three geophone channels worked. Hydrophone channel data intermittent.
OBSA3	2894	175	9/13/90 2043	9/13/90 2115	9/15/90 0513	36°39.597'N	74°54.205'W	34	GPS	652 good tracks; 90 error tracks. Three geophone channels worked. Hydrophone channel data intermittent.

APPENDIX 4

OBH Instrument-Release Table

	Release Serial No. Transmit/Reply Freq. (kHz)	Release Serial No. Transmit/Reply Freq. (kHz)
OBH 16	14511 9/10.5	14734 9/13.0
OBH 17	13652 9/10.0	14143 9/14.0
OBH 18	14134 9/9.5	14142 9/13.5
OBH 19	14118 9/11	14509 9/8.5
OBH 20	14748 9/10	13653 9/8
OBH 21	14744 9/11.5	14737 9/8

APPENDIX 5

Ship Operations

ENDEAVOR operated to the usual extremely high standards of the UNOLS fleet, that we too often take for granted. Navigation and ship handling were excellent, fantail operations were trouble-free despite the lack of one AB, the bosun was always helpful and cooperative and we lost not one minute of time due to failure of any of the ship's systems. It is clear however that a new crane would be a substantial benefit. With a science complement of only eight, accommodations were almost luxurious and the food could not have been better.

The URI Marine technician support lived up to their excellent reputation again. We received substantial help from technician David Nelson with a myriad of little problems. His competence and broad range of expertise contributed to the success of the cruise, especially with regard to the EG&G acoustic transponder system issues. The VAX computers were effective and well used as were the SAIL data (almost exclusively navigation). The ATS system was excellent and played a vital role in our communications network (see Appendix 12).

One of the most important contributions to the success of our operations took place well before we went to sea. Working with commercial survey vessels, who operate on almost no schedule of their own, requires substantial flexibility on the part of the UNOLS ship operator. We could not have asked for better understanding and communication with the URI marine department during the frustrating weeks prior to our cruise when uncertainty was rampant. Without the willingness of Jack Bash and his colleagues to work with us to make a plan that eventually allowed us to meet up with the GECO SEARCHER, our project would have been impossible.

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Appendix 6 Time

1. Time references on R/V Endeavor

To ensure accurate reference time aboard ship, the following devices were in operation:

- SRS-2000 Chronometer
- Arbiter Model 1026C Satellite Controlled Clock
- Kinematics Model 468-DC Satellite Clock.

Throughout this appendix, offsets quoted are positive if the measured time leads the reference time, negative if it lags.

The Arbiter clock tracks the GOES NBS time signal to an accuracy of 10 usec. It has a directional antenna so was used only occasionally to obtain an accurate measure of NBS time. For the purposes of this cruise, the Arbiter is taken as equivalent to NBS time, i.e. it is treated as the correct time.

The SRS-2000 chronometer is WHOI-built clock driven by an Efratom FRS subminiature Rubidium standard. It provides convenient outputs to do various control and timing functions aboard ship.

Figure 1 shows the offset measured during the cruise between the SRS-2000 and the Arbiter NBS time. At the start of the cruise, the SRS-2000 was lagging NBS by 50 usec, by the end it was leading by 200 usec. Thus the SRS-2000 (actually the Rubidium) is running fast compared with NBS.

The True Time clock also tracks the GOES NBS time signal but to a quoted accuracy of 1.5 msec. There are two problems with this clock:

- its time has a diurnal variation which exceeds the 1.5 msec specification,
- if the internal propagation delay is set wrong, much larger errors can occur.

Figure 2 shows a track of offset against time for a True Time clock with the correct propagation delay locked on to the east satellite. Peak-to-peak amplitude is about 8 msec, the mean offset is about -2 msec. In this case the time observed by this system lags NBS time by an average of 2 msec.

Figure 3 shows a track of offset against time for a clock when it switches from tracking the east satellite to tracking the west satellite. Since the propagation delay in this case is correct for the east satellite, when the switch to the west satellite occurs, the time suddenly lags NBS by 20 msec. Other observations confirm that the error under these conditions is fairly consistent at -20 msec.

SRS-2000 vs Arbiter (sns3.dat)

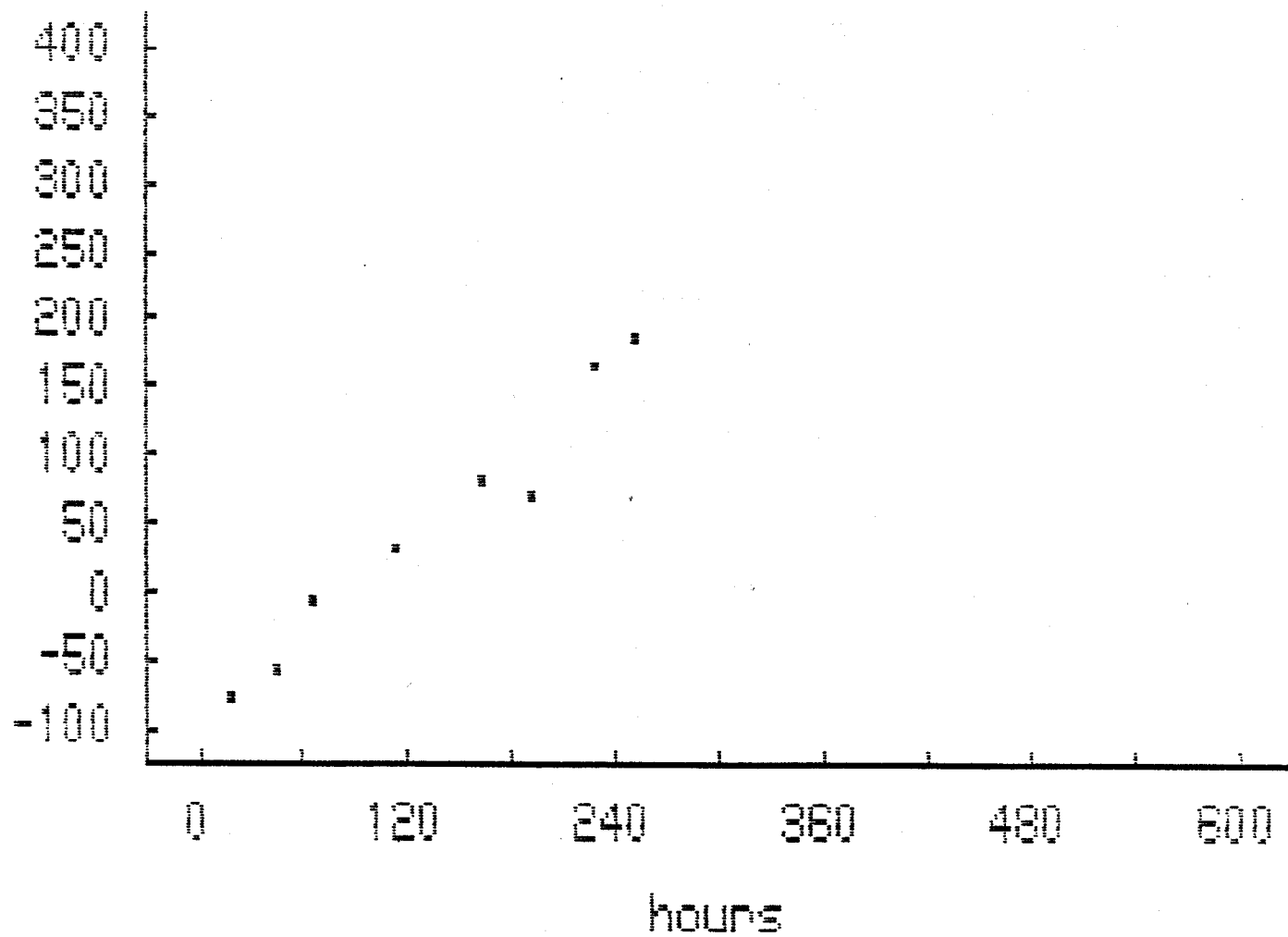


Figure 1

WHOI True Time vs Arbiter (hol4.dat)

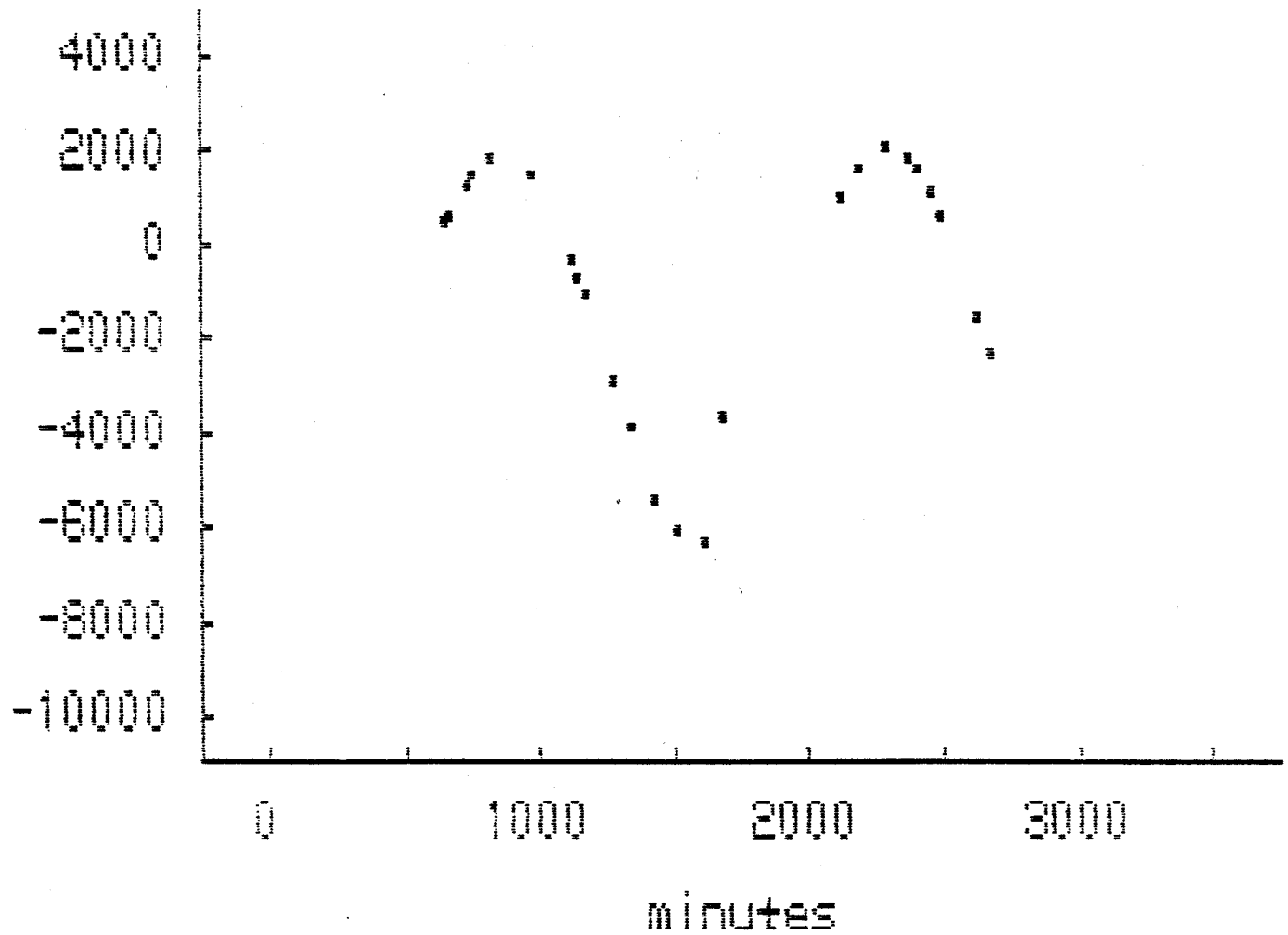


Figure 2

USGS True Time vs Arbiter (usgs1.dat)

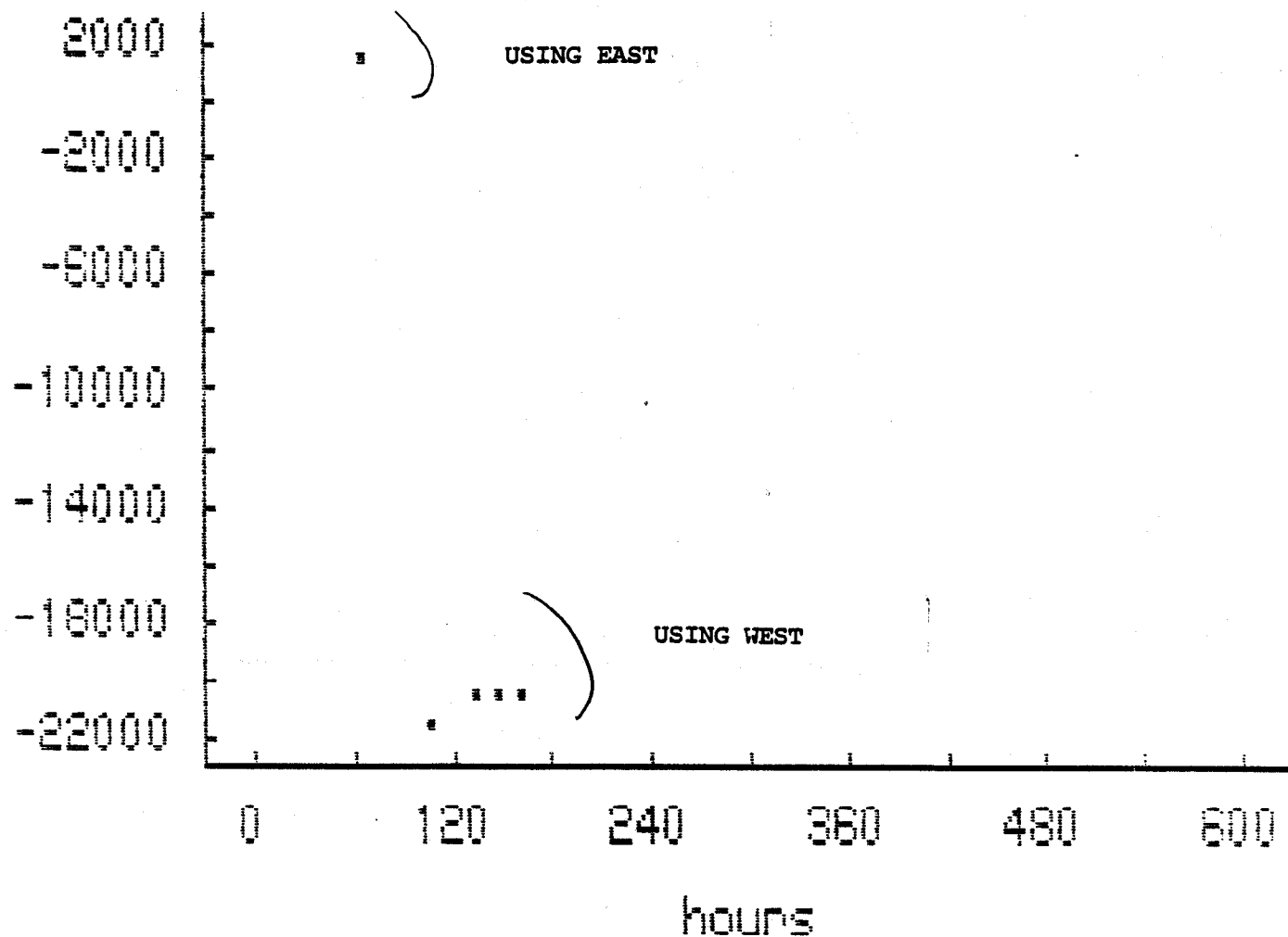


Figure 3

2. Time corrections for shipboard instruments

The clocks in the instruments used aboard R/V Endeavor were set and checked against the SRS-2000 before and after each deployment. Thus the correction necessary is simply that required to correct for the offset measured assuming a linear drift during the deployment. Table 1 lists the actual offsets measured for the instruments.

Table 1. Clock Offsets

Instrument S/N	Before depl't time of check	offset (msec)	After depl't time of check	offset (msec)
16	11 Sept 1021	+4.44	15 Sept 1346	+18.75
17	12 Sept 1246	-11.72	15 Sept 1746	-8.52
18	12 Sept 1012	-2.22	15 Sept 2028	+3.125
19	12 Sept 0228	-11.6	15 Sept 2324	-12.44
20	11 Sept 2340	+0.79	16 Sept 0202	+8.26
21	11 Sept 2003	-9.28	16 Sept 1253	-9.24
A1	12 Sept 1707	-21.45	14 Sept 0002	-16.6
A2	12 Sept 2247	-24.4	(no check)	
A8	13 Sept 0030	-27.0	14 Sept 0340	+0.1
C3	13 Sept 2022	-2.81	(no check)	
C4	13 Sept 1753	-4.05	15 Sept 0907	-3.5
C9	13 Sept 0629	-26.4	15 Sept 1517	-41.2

Thus if the clock error at the start of a deployment was "n" msec, and the offset at the end was "m" msec, the interpolation applies -n msec at the start and -m msec at the end. Thus negative offsets become positive numbers.

It may also be desired to correct for the drift of the SRS-2000 through the cruise using figure 1. Since the deployments were short, this is a flat correction taken from the appropriate point on figure 1. Thus the correction would be -50 usec at the 120 hour point. If this correction is to be made, figure 1 can be correlated to cruise times.

3. Time corrections for other parties

The shot time measurements made aboard GECO Searcher used a True Time clock with an extended accuracy option. It is anticipated that for this clock the equivalent errors to those in figure 2 will be reduced. It is recommended that this unit be tested against the Arbiter clock to establish the magnitude of

the correction needed.

A further complication is that for part of the Searcher operation, the clock was locked on to the west satellite but had the propagation delay set for the east satellite. Again the magnitude of the error caused by this problem must be established. It will be important to try to establish the periods during which the west satellite was being tracked.

The land crew used a WWV receiver to correct their clocks to within 100 usec of NBS time. If this level of accuracy is acceptable and if the corrected times are available, no further corrections are needed.

4. Summary and data reduction procedures

In summary, in the course of data reduction, two time corrections must be applied to the shot instants recorded aboard GECO Searcher, and one time correction to the ocean bottom instruments.

The shot instants must be corrected for

- diurnal variation
- alterations in satellite tracking from east to west.

The magnitude of these corrections will have to be estimated from post-cruise measurements.

The OBS and OBH need only be corrected for instrument drift measured against the SRS-2000, as the magnitude of the Arbiter/SRS-2000 variation is negligible for the purposes of this experiment.

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Appendix 7 - OBH Operations

1. OBH Experience

1.1 Summary

These were new systems which were deployed with only two brief tests in Buzzards Bay prior to the cruise. All systems ran and recorded data as designed. This represents somewhat over 621 megabytes of data recorded apparently without error.

Although there are many improvements needed to achieve convenient, reliable operation, no major changes are indicated. Performance of the batteries and oscillators appear to be within desired limits.

In one unit an assembly problem lead to a blown fuse that caused it to record invalid data. No other operational problems occurred. A problem occurred with the hard disk on several units but it did not inhibit recording or recovery of data.

1.2 Details of deployment preparation problems

On all systems the alkaline battery for the Model 6 sees some load even when the unit is on shore power. The solution was to disconnect the battery until ready to deploy.

The diode board on two units (S/N 17 and 19) was intermittent. The problem in both cases was that the solder posts which are used to connect the ground wire to the battery were not making reliable contact with the circuit board etch. The posts are large and had had the bus wire changed to a larger size. Since the board is single sided, the contact surface area is very small. Both units were made operational by resoldering or by replacing the posts with bus wire directly.

In one unit (S/N 20) there were two connector problems. The low-side connector on the inside of the end cap Mecca was apparently in place but not making contact. The ribbon cable between the Model 6 and the disk was installed wrong giving disk errors. Both problems were easy to repair when identified.

Prior to deployments, the Vectron oscillators all tracked at about 1 part in 10⁻⁸ which was deemed adequate for these deployments. It appeared that they were behaving rationally and could be easily adjusted for better performance. See comments below however.

1.3 Details of post deployment problems

Summary

All systems ran and recorded data as expected.

The data on unit 18 was useless due to a blown fuse in the analog section.

In all cases the systems were running as expected upon recovery so that full debriefing was performed including clock checks.

The performance of the Vectron oscillators is being evaluated - it appears somewhat erratic.

In three cases the disk would not initially spin up during debriefing but later operated correctly.

Battery life appears to be as predicted.

Unit 16

During deployment the oscillator drifted at a rate of about 4 parts in 10⁻⁸. In all lab measurements it had been about 1 part in 10⁻⁸. The new drift is the result of a steeper slope in the same direction as before.

When recovered the disk would not spin up. The error count was one indicating that the problem occurred during recovery. A PPMA (precision percussive mechanical adjustment) brought it back to operation. Data was readback normally - preliminary evaluation says it is good.

Unit 17

During the deployment the oscillator drifted at about the same rate as in the lab but in the opposite direction.

Otherwise, this unit had no problems.

Unit 18

The fuse in the negative analog supply was blown. The problem was a wire that got pinched between the chassis and the pressure case during assembly. As a result the recorded data appears to be stuck at the opposite rail and is useless.

This unit had a problem with its disk similar to unit 16. The same solution appeared to cure it and data were transferred normally.

During the deployment, the oscillator drifted at a somewhat faster rate than in the lab but in the same direction.

Unit 19

During the deployment, the oscillator drifted at a somewhat slower rate than in the lab but in the same direction.

During initial data evaluation, some large repetitive blips were located which appear to be instrumental (not found on nearby instruments).

Otherwise this unit had no problems.

Unit 20

This unit had a problem with its disk similar to unit 16. The same solution appeared to cure it and data were transferred normally.

During the deployment, the oscillator showed almost no change in its drift rate from lab measurements. This is the unit that was used to run the life battery test in the freezer. The long uninterrupted run may have contributed to its good performance.

This unit had a problem with its disk similar to unit 16. The same solution appeared to cure it and data were transferred normally.

During the debriefing test, there was initially no signal getting through the analog section (no negative power to the preamplifier). After some investigation, it began to operate correctly but no explanation was found. The transcribed data indicate that there was no problem while deployed but this needs to be investigated.

Unit 21

During the deployment the oscillator drift changed to almost zero (1 part in 10¹⁰). This may seem good, but in fact it represents a similar problem to the other units - a marked change while deployed. This unit also exhibited a sudden change on a previous occasion after it had been set correctly. Clearly it needs more burn-in but it may be a faulty device.

Otherwise this unit had no problems.

2. Data Retrieval

The Data Strategies International system and the SCSI hard disk were received minutes before the ship sailed. The system was assembled and installed at sea with some problems as outlined below.

During installation of the SCSI system, an operator error caused a corrupted version of the SCSI driver to be loaded onto the computer's C drive. Thereafter when the system booted, it bombed during setup of the driver and was unusable. Booting from a floppy disk got the system back but did not get access to the system's internal hard disk. Our explanation is that it needs a special driver because it is more than 32 Mbytes. Due to another glitch, the system also would not boot from the SCSI hard disk although it should. As a result, we operated by booting from a floppy system then switching to the SCSI disk. This caused little inconvenience except that some software on the system's original hard disk was not accessible.

Offloading from the Onset hard disk directly to the SCSI hard disk works as desired. Backup to the Exabyte and restore to the SCSI hard disk also works successfully. All operations involving the Exabyte are very slow!

There appear to be some bugs in the EXBCOPY program.

When performing a backup immediately after a tape has been inserted (the usual condition), it always finds "no matching

- during assembly, the threaded rod interferes with the Vectron,
- battery replacement is difficult,
- parts removal for service is difficult.

Also reconfiguration may be appropriate with an eye to more routine operations.

3.5 Data recovery

This needs to be made more convenient. Possible approaches are:

- make the Model 6 and disk easy to remove from the frame,
- try using a longer cable to the computer,
- look at high speed serial link (possible future use).

3.6 Clock set/check

A more convenient physical arrangement is needed.

If possible a more automatic method should be designed.

3.7 Easier checkout

Implementation of SAIL and design of better test schemes using signals through the end cap will be helpful.

3.8 Model 6 mod for disk life

The disk manufacturer rates the disk's MTBF for 10000 power up/down cycles. In this application, this represents about 5 full-disk deployments. To improve this, Onset will perform a modification which increases the life by a factor of 4. The modification adds on-board RAM (RAMBO) and provides the necessary changes to BASIC.

This modification should be performed and the minor program changes designed and tested. This impacts the piggyback board since it must provide an opening for the RAMBO's on the Model 6 board. Thus if this is to be done, it should be done before the piggyback board is committed to etch.

3.9 Hardware clock

Although the software clock causes inconvenience, it appears that the complications of changing to a hardware clock make it an unattractive option.

- | | |
|-------|---|
| Pros: | <ul style="list-style-type: none">- use 5 MHz Austron (lower power, but big)- time tagging possible in small buffers- time carried through system reset. |
| Cons: | <ul style="list-style-type: none">- need to create special software clock functions- hardware complication of additional interrupt- software changes to application program- A/D sampling rate poor. |

4. Changes in present support equipment

4.1 Spares

Both electronics and deck spares kits are needed. Much of what is needed could be found in the Bigelow trailers.

4.2 Test gear

The OBH test stand needs to be upgraded as part of the improvements related to easier checkout.

At present we are using borrowed scope, power supplies, and satellite clock.

4.3 Maintenance

The spares kits, the purge kits, and the test gear need to be maintained.

5. Planned changes to OBH

5.1 Recording of actual gain

Need to store the actual gains in each instrument and use these values during processing.

5.2 Increased sample rate

Need to experiment with faster sampling and possibly adjust anti-aliasing filters.

5.3 GRA transitions

Need to look at ways to avoid spectral problems caused by shifts in gain and time-of-sample at gain changes.

5.4 Increased dynamic range

Need to increase gain steps and evaluate the effect. Also select threshold values to use.

6. Other improvements

6.1 Experiment timing

Implement Rubidium-based clock (Koelsch/PC plan).

Also consider GOES or GPS system as reference.

6.2 Recovery

Need receiver/filter and homing system like in the old days!

Should finish the PC/graphic plotter system for recording acoustic tracking.

6.3 Easier-to-use system

Based on cylindrical pressure case and present frame. Solve the readback through the end cap and make internal arrangement more robust. Develop hands-off methods for preparation and debriefing. OK to open case, but can be turned around without opening case if no battery change required.

6.4 Fast deployment system - dream

Electronics in glass sphere with minimum penetrators - seldom opened. Includes transponder/release. Optical through the glass for serial link and clock functions. Fibre optic

penetrator (?) for serial readback. Batteries external. Compact unit with deployable anchor - handled by two men by hand.

7. Documentation Attached

Deployment and Recovery Procedures

Step-by-step procedures used on this cruise for preparation and debriefing. Although these may change when the above changes are made, the main items should be retained.

Acquisition program description

A description of the operation of the program including explanations of the gain ranging and the clock checking.

Acquisition program listing

A listing of the program used for these deployments.

OBH Deployment and Recovery Procedures

1. Standby

shore power (20 v power supply to Vectron and Model 6)
analog power off
Gel Cell on charge
clock set
idling (at menu prompt)

2. Predeployment Preparation

connect serial line to computer
switch to VTERM (or load it if necessary)
check for correct program version

- select "exit program" on menu (6)
- at BASIC prompt, LIST 1-100
- if version 12, OK
- if not, NEW to delete present program
- alt S
- file name ACQ12.BAS
- alt S

switch to battery power

- connect all batteries
- remove jumper between power outputs
- connect Gel Cell
- remove 20v power supply
- check that all batteries are loaded (diode drops)
- turn on analog power

start VTERM log file

- alt R
- file name
- alt R

confirm program version

- at BASIC prompt LIST 1-100

do WHOOP test

- start program, *RUN
- connect WHOOP signal
- check signals on jumper at A/D input
- set for 2v max on low gain channel
- select "acquisition" on menu (1) to track 927
- use ctl C when finished
- select "read data" on menu (2)
- check format of header and first data points

capture WHOOP's

- select "exit program" menu item (6)
- alt A to close VTERM log file
- at BASIC prompt, do OFFLD 0,8192
- alt R
- file name
- change to XMODEM protocol
- alt R
- shell to DOS
- examine file using program OBH

return to instrument preparation

- exit DOS to VTERM
- start program, *RUN
- alt R to start new VTERM log file
- file name
- change back to ASCII protocol
- alt R

do clock check

- connect scope channel 1 to SRS-2000 1 PPS
- connect scope channel 2 to test box 1 SEC OUT
- connect test box to connector on prototype board
- select "clock check" menu item (4)
- wait for "is a goodie"
- measure time between rising edges on scope (ch 2 right of ch 1 = negative, ch 2 left of ch 1 = positive)
- exit with ctrl C

read and record battery voltages while at menu prompt

start experiment acquisition

- select "start acquisition" menu item (1)
- start track = 1 (probably)
- end track = 927 (probably)
- start time depends on experiment
- confirm start time and configuration
- waiting for start time ...
- disconnect test box and serial cable
- close VTERM log file

tube and deploy

- prepare O-ring surfaces
- insert in tube
- purge and set vacuum.

3. Post-recovery Debriefing Procedure

```
remove electronics
  - check vacuum in pressure case
  - open case, remove electronics
set up for debriefing
  - connect serial line to computer
  - connect test box cable
  - start VTERM
  - alt R, to start log file
  - file name
  - alt R
read and record battery voltages
check Model 6 voltages (+ - 5)
wait for next track write or end of recording output
ctl C to get menu
do clock check
  - connect scope channel 1 to SRS-2000 1 PPS
  - connect scope channel 2 to test box 1 SEC OUT
  - connect test box to connector on prototype board
  - select "clock check" menu item (4)
  - wait for "is a goodie"
  - measure time between rising edges on scope (ch 2 right of
    ch 1 = negative, ch 2 left of ch 1 = positive)
  - exit with ctl C
check disk operation (menu item 2 or DFREAD)
close VTERM log file
connect and check simulated hydrophone input
turn off analog power.
offload data
  - connect to computer (power then signal cables)
  - OFFLD6
return to shore power
  - connect to 20v supply
  - connect jumper between power outputs
  - disconnect Gel Cell
```

OBH Acquisition Program

1. Operation

The Ocean Bottom Hydrophone (OBH) acquisition program is written in TT BASIC to run on the Onset Tattletale Model 6. The Model 6 uses a Winchester disk drive for data storage which it fills from a RAM buffer (the datafile) whose size equals one track on disk. The system also includes an analog-to-digital converter with an eight-channel multiplexer and a real time clock.

Separate electronics provides signal conditioning for up to four sensors with two amplifiers per sensor so that the A/D converter receives signals from each sensor at two different gain levels. These are used for gain ranging - see section 2.

The program operates in one of several modes from the menu shown in table 1. Note all operator entries must be in upper case.

Table 1. Operation Menu

OBS OPERATION MENU

- (1) Start acquisition
- (2) Read header data and sample data
- (3) Set clock.
- (4) Read clock.
- (5) Set header info.
- (6) Exit program.

CONTROL-C RETURNS THIS MENU

ENTER DESIRED SELECTION NUMBER

Menu item 1 - start acquisition - is selected to start acquisition of data. When this item is selected, a start time is requested followed by the start and stop tracks to be used on the disk. The system then enters a wait mode until the start time occurs. After that, acquisition occurs until the disk is full or the specified tracks are recorded. It then enters a low power wait mode until a control C from the operator returns it to the menu.

Menu item 2 - read data - is selected to allow a specific track to be read from the disk for test purposes. The whole track is read in to the datafile then the data header and the first few data samples are listed. This is used as a check that the disk is working correctly. After reading and displaying the header, the system returns to the menu. Note, more complete sections of the data can be read and captured for processing by exiting from the program and using the BASIC OFFLD command.

Menu item 3 - set clock - is selected to set the real time clock. This is required only in the following circumstances:

- initial power up
- if the clock has been corrupted by certain system functions such as writing to the EEPROM
- if for any reason it is necessary to perform a processor reset.

The desired clock set time is requested then the system waits for a hardware edge to start the clock. The program then returns to the menu.

Menu item 4 - read clock - is selected to allow the internal real time clock to be compared with an external reference for drift calculations. The system outputs the time every second until a sync second occurs - see section 3. Thereafter it outputs a hardware tick as well as the time every second for accurate comparison with an external time reference. This output continues until interrupted by a control C.

Menu item 5 - set header info - is used to enter information which will be included in the header of every track on disk. At present no useful information can be added although the header does contain necessary information - see section 5. After the data is entered, the program returns to the menu.

Menu item 6 - exit program - is used to return to the BASIC system. This is necessary because the program is normally run using the special Tattletale function *RUN which interprets the control C function as a return to line 100. To return to the program after using the exit item, type *RUN.

2. Gain Ranging

A special feature of the program is real time gain ranging of up to four sensor channels which works as follows. The eight multiplexer channels are treated as pairs each of which represent two different gain states of the same sensor input. A software algorithm selects one of the two inputs for recording and normalizes the recorded value. This is performed on a sample-by-sample basis during acquisition so that only one sample is recorded from each pair of channels. Thus additional dynamic range is achieved without consuming data capacity.

Program parameters are stored which tell:

- if a given pair of channels is in use
- the gain difference between each channel in a pair
- the threshold value to use for switching.

In operation, both channels are converted but only one is stored. The higher gain channel (assumed to be the second of each pair) is compared with the threshold. If it is greater than the threshold, the lower gain channel (multiplied by the gain

factor) is stored. Otherwise the high gain channel is stored unchanged. The result is a data record with normalized values.

As an additional part of this function, it is possible to obtain burst sampling if fewer than eight channels are in use. By convention, if the gain parameter is set to unity for a given channel pair, they will be converted but neither value stored. As a result, the channels which are in use will be converted and stored at the A/D rate with time gaps between conversions which correspond to the channels which are converted but not stored.

Thus for example if the converter is run at 1600 samples per second with only one sensor in use and the remaining channels are set to unity, the two conversions for this channel will be separated by only 625 usec but separated from the next conversions for this channel so that the actual rate is 200 samples per second.

3. Clock Set/Check

The Onset Model 6 uses a software clock based on the processor's counter/timer registers. Since for this application it is necessary to set and read the clock to an accuracy of better than one millisecond, special methods are needed. This section describes the scheme used.

The clock count chain starts from a pulse which occurs at a 10 msec rate. These pulses are counted with an 8 bit counter which thus rolls over every 2.56 seconds. The BASIC system software uses these rollovers to generate a count of the number of 10 msec intervals since 1 January 1980. From this it maintains time of day which is stored in a 5-byte variable as follows:

- second (0 to 59)
- minute (0 to 59)
- hour (0 to 23)
- day (1 to 31)
- month (1 to 12)
- year (0 to 99).

BASIC instructions are provided to set and read the clock by accessing these variables. However, due to the slow cycle time of the BASIC instructions it is not possible to know the actual time to better than several milliseconds.

To set the clock more accurately than is possible with BASIC, this program uses a rising edge connected to bit D13 which is detected by an assembly language loop. To set the clock, the desired set time is entered by the operator then the program waits in an assembly language loop for the rising edge on D13. When the edge occurs, the assembly language detects it within a few microseconds (assembly language instruction time). At this point the program does the following:

- sets the D12 bit
- returns to BASIC

- sets the clock
- resets the internal interval counter
- clears the D12 bit.

In this way, the jitter on the actual time set is limited to the time of the assembly language instructions. Also by observing the D12 bit with an oscilloscope, the actual time set can be bracketed.

To check the clock, it is necessary to generate a hardware edge that is accurately related to the internal time. The method used is based on the fact that the 10 msec counter rolls over (i.e. goes from 255 to 0) on a one second boundary every 64 seconds and at predictable times every day. When one of these seconds occurs, it is known that the counter is at zero and that second boundaries occur thereafter whenever the count has changed by 100 (modulo 256).

Thus the clock check is performed as follows:

- read clock
- determine if current second is a "good" one
- if not, read clock again
- if so, start tracking 10 msec counter in assembly language
- when counter changes by 100, generate tick on D12
- observe D12 on oscilloscope against time reference.

4. Data Time Tag

In order to enable the recorded data to be processed, it is necessary to accurately identify the time of occurrence of one sample in each datafile. This is done by waiting for one of the "good" seconds as described in section 3 then storing the current value of the current datafile address which is available from the A/D control array. This is stored in the header along with the time as the data time tag. The address is called the pointer since it points to the sample that corresponds to the time recorded.

5. Data Format

Each track of data is treated as a file with a header followed by a large data block. The total size is 229376 bytes of which the header uses 160 bytes and the data block uses 229216 bytes.

The header format is in table 2.

The data format is simply 114608 2-byte samples. For a gain difference of 20 dB, the values are from -20480 to 20470 which represent the range of -5 to +5 volts. Thus to convert the raw recorded values to equivalent volts, multiply by 0.00024414. Note these voltage values are equivalent to those seen on the low

gain channel in the instrument since the high gain channel has the gain factor removed during normalization.

6. Variables

Tattletale BASIC provides single letter variables (A to Z), a variable length integer array represented by the symbol '@', and user memory locations. Table 3 has a list of the variables used and their function. Note, some are used for more than one function.

7. Subroutines

Table 4 is a list of the location and function of the subroutines in the program.

Table 2. Header Format

Byte #	Size	Use
1-2	2	pointer time - hour (data time tag)
3	1	": "
4-5	2	- minute
6	1	" "
7-8	2	- second
9-10	2	" "
11-12	2	- year
13	1	"/ "
14-15	2	- month
16	1	"/ "
17-18	2	- day
19-20	2	<cr><lf>
21-29	9	"POINTER "
30-35	6	pointer value (between 160 and 229376)
36-37	2	<cr><lf>
38-46	9	"UNIT SN #"
47-49	3	unit serial number
50-58	9	" TRACK #"
59-61	3	track number on disk
62-63	2	<cr><lf>
64-71	8	"GAIN: H "
72-75	4	hydrophone gain
76-79	4	" , X "
80-83	4	x-axis gain
84-87	4	" , Y "
88-91	4	y-axis gain
92-95	4	" , Z "
96-99	4	z-axis gain
100-101	2	<cr><lf>
102-108	7	"START: "
109-110	2	acquisition start time - year
111-112	2	- month
113-114	2	- day
115-116	2	- hour
117-118	2	- minute
119-120	2	- second
121-122	2	<cr><lf>
123-127	5	"ERR: "
128-129	2	disk error counter
130-131	2	<cr><lf>
132-136	5	"REC: "
137-138	2	receiver number (same as serial number)
139-140	2	<cr><lf>
141-145	5	"EXP: "
146-151	6	experiment identification ("CHESxx")
152-153	2	<cr><lf>
154-158	5	" "
159-160	2	<cr><lf>

Table 3. Variables

Variable	Function(s)
A	assembly language label temporary
B	assembly language label temporary
C	assembly language label
D	assembly language label track counter temporary
E	assembly language label end track number
F	assembly language label temporary
G	assembly language label
H	receiver number
I	hydrophone gain
J	x-axis gain
K	y-axis gain
L	z-axis gain
M	number of active channels
N	menu item selected
O	number of hidden channels
P	pointer time
Q	disk error counter
R	sample rate value
S	start track number
V	temporary
W	temporary
X	temporary
Y	disk error flag
Z	disk error flag
@(40)	threshold
@(41)	channel 1 gain/flag
@(42)	channel 2 gain/flag
@(43)	channel 3 gain/flag
@(44)	channel 4 gain/flag
112,113	data value temporary storage
121-124	pointer value temporary storage
125	temporary storage

Table 4. Subroutines

Address /line no.	Type	Function
2000	BASIC	set up A/D parameters
8000	BASIC	get Y/N answer from operator
10000	BASIC	find "good" second
15100	BASIC	assemble assembly language routines
114	assembly	store data into datafile
4000	assembly	gain ranging channel processing
4100	assembly	detect rising edge on D13
4120	assembly	set up for counter at zero
4130	assembly	track counter 100 modulo 256

```

1 REM VERSION 12:CHES02
3 REM VARIABLES USED: A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P,
4 REM Q, R, S, T, V, W, X, Y, Z
20 ASM16,DB 5:FOR M=0TO10:NEXT M
30 VGET @(31):REM GET SERIAL NUMBER
40 XSHAKE1000:H=1:I=1:J=1:K=1:L=1
50 @(32) = 0:GOSUB 2000:REM SET UP ADLOOP
80 A=0:B=0:C=0:D=0:E=0:F=0:G=0:Q=0:GOSUB 15100:GOSUB 15100
90 GOTO 110
00 GOTO 200
10 @(40)=16300,@(41)=10,@(42)=1,@(43)=1,@(44)=1
30 M=0:O=0:FOR A=41 TO 44
35 IF @(A) <> 0 O=O+1
40 IF @(A) > 1 M=M+1
45 NEXT A
50 R = 16
60 PRINT'SETTINGS: ',M,' CHANNELS, ',(R*50)/O,' S/S/CHAN'
70 RATE R
80 X=0:FOR A=1 TO 100:STORE X,0:NEXT A
90 GOTO 100
100 PRINT:PRINT'OBS OPERATION MENU':PRINT
110 PRINT'(1) Start acquisition'
120 PRINT'(2) Read header data and sample data'
130 PRINT'(3) Set clock.'
140 PRINT'(4) Read clock.'
145 PRINT'(5) Set header info.'
150 PRINT'(6) Exit program.'
160 PRINT'CONTROL-C RETURNS THIS MENU'
265 @(32) = 0:GOSUB 2000
270 INPUT 'ENTER DESIRED SELECTION NUMBER 'N
280 IF N>6 GOTO 200
290 IF N=1 GOTO 340
300 IF N=2 GOTO 910
310 IF N=3 GOTO 5000
320 IF N=4 GOTO 6400
325 IF N=5 GOTO 3000
330 IF N=6 STOP
340 INPUT'ENTER STARTING TRACK # 'S
350 IF S=0 S=1:REM DON'T OVERWRITE TRACK 0 INFO!
360 INPUT'ENTER ENDING TRACK # 'E
370 PRINT:PRINT 'To set start time for data acquisition':PRINT
380 INPUT 'Enter year (0-99) '? (5)
390 INPUT 'Enter month (1-12) '? (4)
400 INPUT 'Enter day (1-31) '? (3)
410 INPUT 'Enter hour (0-23) '? (2)
420 INPUT 'Enter minute (0-59) '? (1)
430 ?(0) = 0
440 PRINT:PRINT ' Start time is ';
450 PRINT ?(5),'/',?(4),'/',?(3),' ',#02,?(2),':',#02,?(1),':',#02,?(0)
460 GOSUB 8000
470 IF D=78 GOTO 370
480 STIME @(12)
490 PRINT'Acquisition: ',M,' channel(s), at ',(R*50)/O,' samples/sec/chan'
500 GOSUB 8000
510 IF D=78 GOTO 100
515 @(32) = -1
520 PRINT 'Waiting for start time ';
530 SLEEP R*100: RTIME: IF B = ?(0) GOTO 530

```

```

40 B = ?(0):TIME A
50 PRINT ' ';
60 IF A < @(12) GOTO 530
70 ADLOOP
80 PRINT: PRINT 'Acquisition started'
90 PRINT 'Finding initial sync ';
00 GOSUB 10000
10 P=@(34):RTIME
20 FOR D=S TO E
30 PRINT:PRINT:PRINT'TRACK HEADER STORED AS : '
40 X=0:STORE X," ",{0,156}
50 X=0:STOREX,'',#02,?(2),',',#02,?(1),',',#02,?(0);
60 STOREX,'',#02,?(5),',',#02,?(4),',',#02,?(3)
70 STOREX,"POINTER ",#6,P
80 STOREX,'UNIT SN #',#03,@(31);
90 STOREX,' TRACK #',#03,D
91 STOREX,'GAIN: H ';
92 STOREX,'',#04,I,'', X ',#04,J,'', Y ',#04,K,'', Z ',#04,L
95 RTIME @(12)
96 STOREX,'START: ',#02,?(5),?(4),?(3),?(2),?(1),?(0)
97 STOREX,'ERR: ',#02,Q
98 STOREX,'REC: ',#02,@(31)
99 STOREX,'EXP: CHES02'
00 PRINT(0,159)
20 SLEEP R*100
30 IF @(34)<16384*7-1 GOTO 720
40 PRINT\7,'WRITING TRACK ',D,'-0 NOW'
50 IF E=0 PRINT'WRITE OPERATION SUPRESSED':GOTO 780
60 DFSAVE D,Y,0
70 IF Y<>0 Q=Q+1:PRINT'DISK ERROR AT TRACK # ',D
80 SLEEP R*100
90 IF @(34)>16384*7-1 GOTO 780
000 REM SYNC TO SECOND
10 GOSUB 10000
20 P=@(34):RTIME
30 PRINT\7,'WRITING TRACK ',D,'-1 NOW'
40 IF E=0 PRINT'WRITE OPERATION SUPRESSED':GOTO 870
50 DFSAVE D,Z,1
60 IF Z<>0 Q=Q+1:PRINT'DISK ERROR AT TRACK # ',D
70 NEXT D
80 @(32)=0:D=D-1
90 PRINT'END OF DATA RECORDING':PRINT
00 SLEEP R*1000:PRINT ' ',D,' ',Q:GOTO900
05 GOTO 100
10 INPUT 'ENTER TRACK TO READ 'F
20 PRINT' TRACK # ',F:DFREAD F,Z
30 PRINT' HEADER AND INITIAL SAMPLES:'
40 PRINT:PRINT(0,159)
50 X=160:V=R*10
60 FOR A=1 TO 5
70 X=X+2
80 B=GET(X,#2):IF B>32767 B=B-65536
90 PRINT#8,F,A,B
010 SLEEP V
020 NEXT A
030 GOSUB 8000
040 GOTO 100
000 REM ** SET UP ADLOOP **

```

```

6 @ (33)=0,@ (35)=2,@ (37)=(7*32768)-1,@ (38)=&H4000,@ (39)=0
0 @ (34)=160
0 @ (36)=160
0 GOSUB 31125
0 RETURN
00 REM ** SET HEADER INFO **
0 INPUT 'ENTER RECEIVER NUMBER (4 DIGITS) 'H
0 INPUT 'ENTER HYDROPHONE GAIN 'I
0 INPUT 'ENTER X-AXIS GAIN 'J
0 INPUT 'ENTER Y-AXIS GAIN 'K
0 INPUT 'ENTER Z-AXIS GAIN 'L
0 GOTO 100
00 REM ** SET CLOCK **
0 PRINT
0 PRINT 'To Set And Start System Clock:'
0 INPUT 'Enter Year (0-99) '? (5)
0 INPUT 'Enter Month (1-12) '? (4)
0 INPUT 'Enter Day (1-31) '? (3)
0 INPUT 'Enter Hour (0-23) '? (2)
0 INPUT 'Enter NEXT Minute (0-59) '? (1)
0 ? (0)=0:REM TO START CLOCK ON EVEN MINUTE
0 PRINT
0 INPUT 'To Start Clock, Press Any Key (External Pulse Will Then Sync) 'A
0 CALL &H4100,0
0 SLEEP 0: REM SHOULD BE THE ONLY SLEEP 0 IN THE CODE!!
0 STIME
0 PCLR 12
0 GOTO 100
00 REM ** READ CLOCK **
0 CALL &H4120,0: REM SET SUB SECOND COUNTER TO 00
0 RTIME: REM NOW WAIT FOR A "GOOD" SECOND
0 IF B=? (0) GOTO 6420: REM THAT IS, A MULTIPLE OF 64
0 B=? (0): REM (EACH DAY HAS 1350 OF THEM)
0 PRINT
0 A=? (2)*3600 + ? (1)*60 + ? (0) + 1
0 PRINT #5,? (2),? (1),? (0);
0 IF A % 64 <> 0 GOTO 6420
0 PRINT ' is a goodie';
0 PRINT
0 CALL &H4130,0
0 PSET 12
0 FOR S=1 TO 100:NEXT S
0 PCLR 12
0 RTIME
0 PRINT 'Time ',#02,? (2),':',#02,? (1),':',#02,? (0);
0 IF ? (0)=0 PRINT ' Date ',? (5), '/',? (4), '/',? (3);
0 GOTO 6500
0 GOTO 100
00 PRINT 'Is this correct (Y/N)? ';
0 W=1
0 ITEXT W
0 W=1
0 D = GET (W,#1)
0 IF D = 89 RETURN
0 IF D = 78 RETURN
0 GOTO 8010
0000 CALL &H4120,0: REM SET SUB SECOND COUNTER TO 00
0010 RTIME: REM NOW WAIT FOR A "GOOD" SECOND

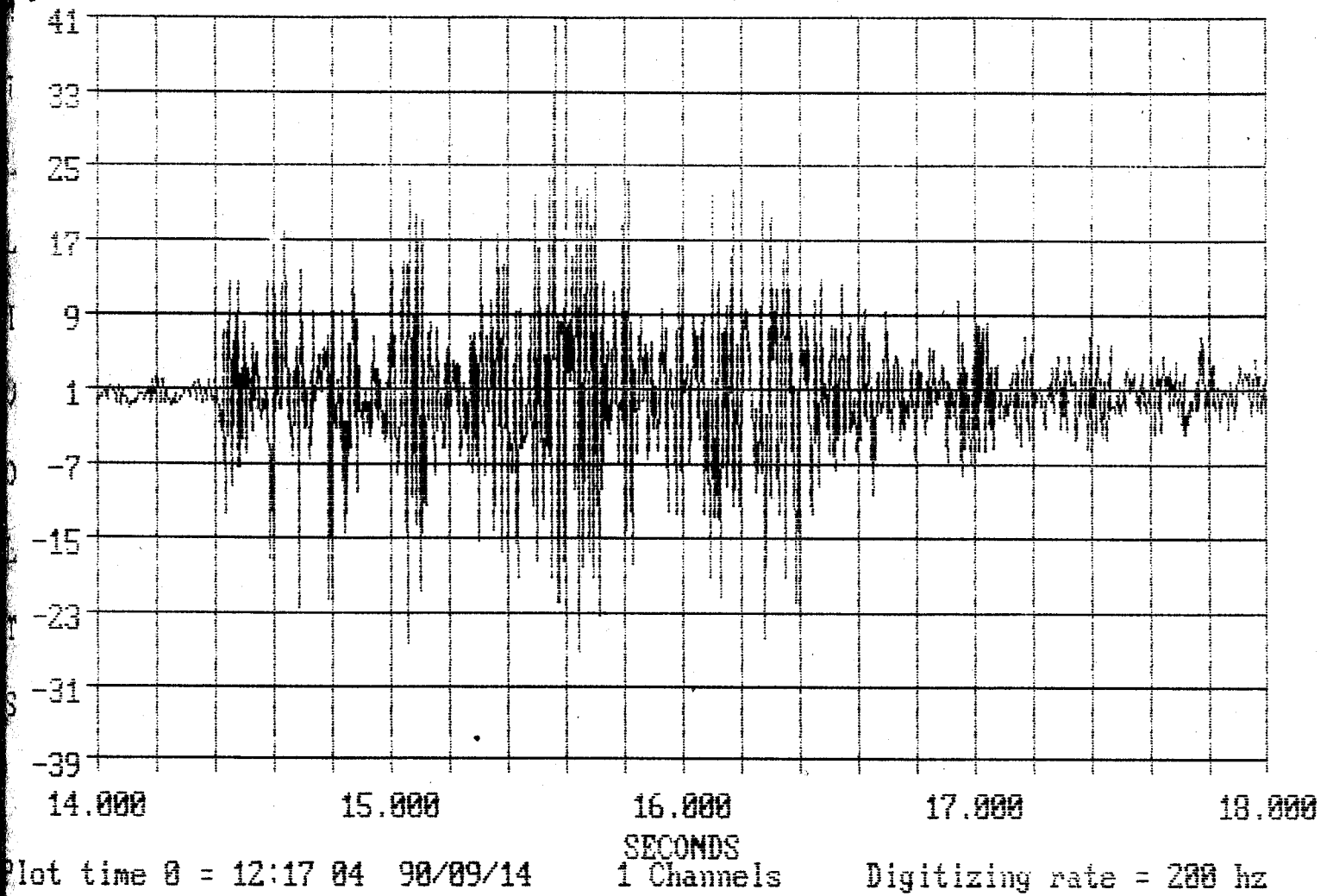
```

```

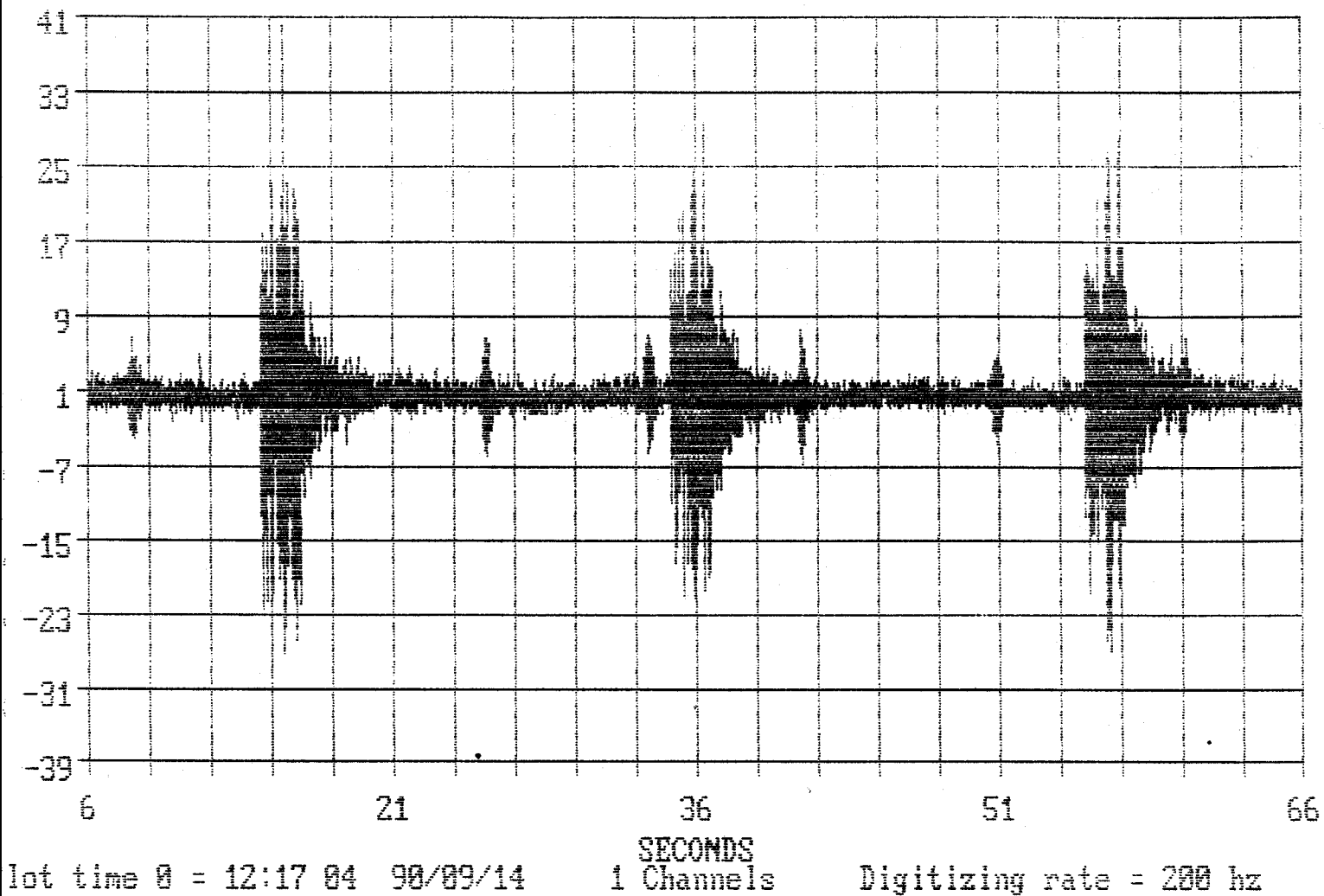
020 IF B=?(0) GOTO 10010:REM THAT IS, A MULTIPLE OF 64
030 B=?(0): REM (EACH DAY HAS 1350 OF THEM)
040 A=?(2)*3600 + ?(1)*60 + ?(0) + 1
045 PRINT ' ';
050 IF A % 64 <> 0 GOTO 10010
055 PRINT:PRINT #5,?(2),?(1),?(0)
060 CALL &H4130,0: REM WAIT FOR START OF "GOOD" SECOND
070 RETURN
100 REM ** FIND SUB-SECOND ROLL OVER ***
120 X=&H4120: REM SET UP FOR ? OVERFLOW
130 ASM X,CLRA
140 ASM X,STAA &H13F: REM SET COUNTER TO ZERO
170 ASM X,RTS
180 REM
190 X=&H4130: REM WATCH FOR ? TO PASS COUNTER
200 F=X:ASM X,LDAB &H43
210 ASM X,SUBB &H13F
220 ASM X,BNE F: REM WAIT IF NOT THERE YET
230 ASM X,LDAB &H43: REM NOW PAST COUNTER
240 ASM X,ADDB #&H64: REM ADVANCE COUNTER 100
250 ASM X,STAB &H13F: REM STORE FOR NEXT TIME
300 ASM X,RTS: REM RETURN WHEN VALUE FOUND
310 REM
0000 X = &H4100: REM WATCH FOR TICK ON D13
0010 ASM X,LDAB #&H2: REM SET BIT 1 TO 1
0020 ASM X,STAB &H08: REM SET FOR RISING EDGE TRIGGER
0022 ASM X,STAB &H1: REM SET DDR REG
0024 ASM X,STAB &H8A: REM BASIC'S COPY
0030 ASM X,LDAA &H0D: REM CLEAR FLAG FROM LAST TIME
0040 G=X:ASM X,LDAA &H08: REM READ CTR REG
0050 ASM X,ANDA #&H80: REM EXTRACT TOP BIT
0060 ASM X,BEQ G: REM LOOP IF NOT SET
0062 ASM X,LDAB #&H02: REM SET BIT P21
0064 ASM X,STAB &H03: REM OUTPUT THE BIT
0070 ASM X,RTS: REM RETURN IF SET
0080 REM
0000 REM
0005 X=&H4000
0010 ASM X, LDAB &H718F
0020 ASM X, INCB
0030 ASM X, ANDB #&H07
0040 ASM X, STAB &H718F
0050 ASM X, ANDB #1
0060 ASM X, BNE B
0065 REM *** LOW GAIN CHANNEL PROCESSING ***
0070 REM - right justify the data and store it
0080 ASM X, LDD &H7196
0090 ASM X, ASRA
0100 ASM X, RORB
0110 ASM X, ASRA
0120 ASM X, RORB
0130 ASM X, ASRA
0140 ASM X, RORB
0150 ASM X, ASRA
0160 ASM X, RORB
0170 ASM X, STD &H112
0179 REM - get multiplier by calculating
0180 ASM X, LDAB &H718F

```


FILE = CHES0217.D2 - TRACK DUMP # 10



Shipboard QC plot of four second data sample from OBH 17.



Shipboard QC plot of a one minute long section of data from
OBH 17 showing the arrivals from multiple shots.

APPENDIX 8

USGS OBS System, G. Miller and M. Martini

SYSTEM OVERVIEW

The USGS OBS has been designed as a continuous recording system setup to acquire signals from one vertical 4.5 Hz geophone, two horizontal 4.5 Hz geophones (oriented at ninety degrees from each other), and one hydrophone. The software controlling the system can select any combination of these four channels to sample at 200 Hz. Once during each acquisition of data into the memory buffer (229, 376 bytes), the system will record the time of the sample. The time and the data pointer for that time are saved in a 160 byte header that gets recorded at the beginning of each track. The software controlling data-acquisition is compatible with ACQ5.BAS used in the WHOI OBH. Only the gain selection for the OBS preamps has been added. The data format is identical with the OBH.

SYSTEM LIMITATIONS

The limitations of the USGS OBS can be described in three general categories: analog circuitry, power, and software. These limitations determine the conditions under which the OBS can be successfully operated (hopefully). With the current system, configuration options are limited to continuous record mode only, a fixed 200 hertz acquisition rate, no more than a 12 hour delay before recording data, and a thirty-six hour limit on the total record time (4 channels).

The analog circuitry limitations begin with the instrument preamps. These preamps are digitally controlled (gain settings of 10, 100, or 1000) devices setup with a differential input front-end. Unfortunately, there is no signal conditioning on any of the preamps except for damping resistors necessary for the geophones. The damping resistors should be placed across the inputs to the preamp, but in this design, the damping resistors are connected between the signal input and ground (defeating the purpose of using a differential input design). The hydrophone preamp has been reworked to eliminate the 1 Megohm resistors going to ground. Two 5 Megohm resistors have been added to increase the front-end impedance. The results from this cruise should give some indications of the effectiveness of this change. AC coupling caps have been added to all preamps to remove the DC offset from the preamp signals. The geophone preamps need to have the front-end impedance increased, and the damping resistor needs to be moved to connect between the two inputs (isolating the inputs from ground). The high impedance front-end should bring more consistency to the system gain values and improve the low frequency response of the geophones. An AC coupling cap should be added to the front-end of the hydrophone preamp as well as some protection circuitry to prevent overloading the preamp. The low-pass filter is a highly modified version of a standard 2-pole bezel filter. This filter provides only 12 dB/octave filtering which is not sufficient for anti-aliasing. This filter, also, does not have a very flat response for the signals that are not filtered. This problem can be solved by using an 8-pole Butterworth to provide 48 dB/octave rolloff. Resistor headers can be used to set the rolloff frequency.

The power distribution system is probably the biggest limitation of the system. The battery pack provides 9 stacks of alkaline cells at +12 volts. The nature of alkaline cells is that the operating voltage provided under load is actually between +12 volts and +11 volts when new. This presents a problem in that the OBS circuitry really needs a voltage above +12 volts to provide good regulation. The Vectron oscillator currently operates directly off

the battery voltage (there is no regulation). This means that the Vectron is powered from the outset with a voltage that is below the oscillator's spec. This problem gets worse as the battery's output voltage drops with use. The hard-disk on the Tattletale is another problem. In cold temperatures, the hard disk will fail if the supply voltage drops below 10 volts. This severely limits the amount of useful power that can be provided to the OBS electronics. Another problem in providing power is the Gel-cell battery currently used to maintain power to the Vectron (and everything else). This battery is wired directly inline with the main battery. There is no protection or isolation of this battery with the main battery pack. There is also no regulation of the voltage charging the Gel-cell. This means that the Gel-cell is constantly being charged with a voltage lower than is required to charge the battery (i.e., as the main battery drains, the Gel-cell also drains). The Gel-cell problem can be corrected by adding protection diodes to all of the various power inputs to the system. Better charging characteristics can be achieved by adding a regulator/charging circuit to the power input of the Gel-cell. The output voltage of the main battery pack must be increased. With a higher input voltage, a regulator can be added to the input of the Vectron to improve the accuracy of the system timing. The question is how to increase the voltage of the main battery pack. The easiest solution is to use Lithium batteries. A double "D" battery has three times the AmpHour capacity as two "D" size alkalines, is lighter, has a 13 to 15 volt operating voltage, and the voltage is relatively flat for the life of the battery. These batteries, however cost \$20 per cell versus the \$2 for 2 "D" size alkalines. To use alkaline cells effectively in this system the voltage would have to be 18 volts to supply enough "head" room for the voltage regulators. The battery packs could be redesigned to accommodate a +18 volt battery, but it will have only 60 AmpHours instead of 90 AmpHours. Even with less capacity, the OBS may have a longer bottom time, since it can use more of the battery's capacity. Also the power supply for the analog circuit needs redesign. The current system does not provide good voltage regulation and the negative inverter adds considerable noise to the amplifiers. The solution is simply to install fixed 100 ma regulators at +5 volts and -5 volts (using a separate battery for the negative voltage). The 5 volt rails will ensure that the signals do not exceed the voltage rails of the A-D converter of the Tattletale. This requires rethinking the amplifiers used in the circuit. One option is to use amplifiers that are linear (gain) up to the rails to use the maximum amount of resolution available. The second option would be to set the references on the A-D to ± 2.5 volts instead of 5 volts. This would maximize the amount of resolution available using existing amplifiers.

The software limitations really reflect hardware changes. The biggest change is to upgrade the Tattletale6's to Tattletale6A's to increase the data buffer from the existing one-quarter Megabyte to one Megabyte. This increase in buffer size will extend the life of the hard disk by a factor of four. This will require an upgrade to the existing TT BASIC ROM to accommodate the new datafile size, and new considerations need to be made about time tagging the data with the larger buffer. When the anti-aliasing filter situation is remedied, new routines can be added to select the sample rate of the data. Also no header information format has yet been established. If data file compatibility is to be maintained with the WHOI OBH, a header format is necessary to log instrument information.

POST DEPLOYMENT NOTES

All six OBS's were deployed along line CHES02. All six returned, although OBS C-9's release will have to be gone through thoroughly before it is deployed again. Of the six systems, only two recorded all the way through (A-1, A-8), one failed to write any records (A-2), one failed after 921 tracks (C-4), one failed after 817 tracks (C-9), and one failed after 742 tracks (C-3). Two systems (A-2, C-3) would not respond when retrieved, and could not get either track information or time synch data. The other four systems yielded clock drifts from 3 to 8 parts in ten to the eighth. This number is reasonable considering

the method I currently use to calibrate the oscillators. To improve this, I need to find some way of keeping all the systems powered (this requires redesign of the power structure in the OBS) and acquire the equipment (Rb standard and an accurate counter) needed to set the oscillators. Given the amount of drift in our True Time clock, I need to rethink how to establish an accurate time base in the field. The early end of acquisition in most of the OBS's was not unexpected. This failure is related to the limitations of the power system presently used. There were a large number of disk write failures (from 9 to 42 bad tracks) that occurred all through the data record of all OBS's. These do not appear to be related to any power limitations. All systems were tested and the tracks could be successfully written to after the deployment. The cause for this failure and the complete failure of A-2 is unknown at this time. The geophone data looked okay in all systems. The signal to noise ratio can be improved in these sensors, but for now the data appears to be good. The improvements to the hydrophone channel did not work well. There is data present, but mostly when the shooting ship was close to the instrument. This preamp design needs a complete rework.

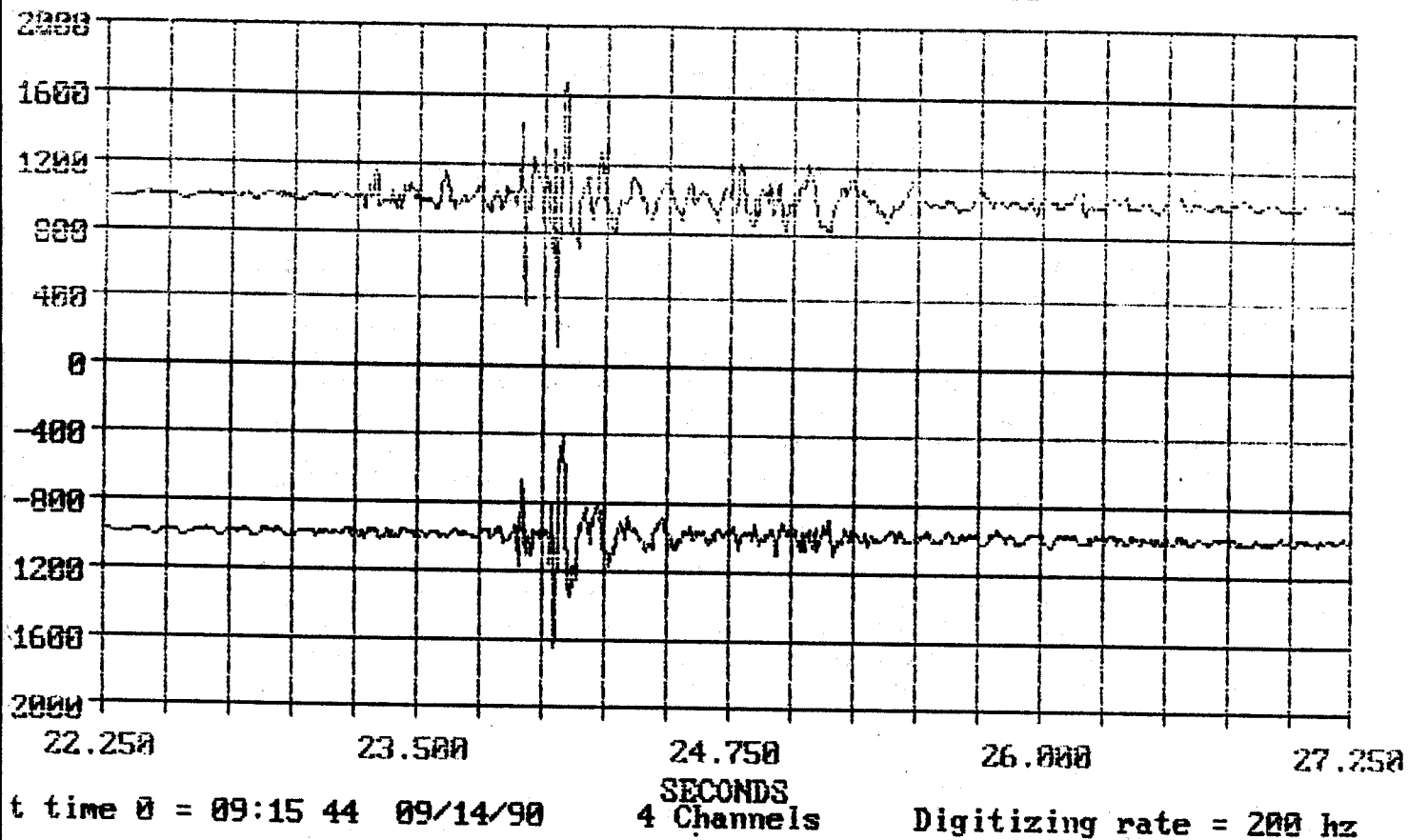
CURRENT VIEW OF WORK THAT NEEDS TO BE DONE ON USGS OBS's

1. Establish the research function of the instruments. Before making any changes in the existing system, some definition of what the system is expected to do in the field is needed. Specifications are extremely helpful in determining the most suitable solution to existing problems.
2. The analog circuitry needs to be completely reworked. To make room on the Tattletale prototype board (to improve the mounting for the Vectron), I recommend that all of the analog circuits be moved to a separate board(s) that is mounted directly on top of the geophone housing. More room will be needed to mount the new filters, so why not move the circuits as close as possible to the sensors and cut down on the number of cables?
3. The power structure needs to be completely redone, using a higher battery voltage, better protection and regulation of the various power sources, and a new power scheme for the analog circuits.
4. The metal plate used to mount the electronics is an extremely cumbersome way of handling the system. Since the plate has not provided any vibration elimination capabilities, I suggest getting rid of it and returning to a clamp-in type of frame. This will provide us with a larger mass to deal with in isolating the noise, easier to insert and remove from the sphere, and make it more space efficient when testing the units.
5. Upgrade all Tattletales to 1 Megabyte of memory. This will increase the life of the hard disk by a factor of four.
6. Add the full header information to the data format.
7. Establish equipment and procedures to properly support the Vectron oscillator, and establish a procedure for evaluating time-of-day.
8. Write Exabyte software to write data tapes that can be read on any computer with an Exabyte drive.

9. Acquire a second computer (a laptop?) that can be used to communicate with the OBS's while the main computer is relocating data in all of the places that are needed to eventually get the data to tape.

CH4

FILE = CHES02AB.D2 - TRACK DUMP # 100



A shipboard QC plot of 5 seconds of OBS data. Upper trace is horizontal component, lower is vertical.

clock labelled "East" was lit. Unfortunately, the clock did not always stay locked on the "East" satellite, despite the fact that I had the antenna oriented in the optimum direction to receive the "East" satellite. On occasion, for a period of about a minute, both the east and west lights on the clock were lit. I was also surprised to notice that not once during a 360 turn on line MA801 did the clock to unlock from the "west" satellite. I also tried switching off and switching on the clock; the clock restarted locked on the east satellite but soon switched over to the "west" satellite. When I was alerted to this possibility by Mike Purdy I logged which satellite my receiver was listening to.

Should this type of "piggyback" experiment be repeated, I recommend the use of a portable PC instead of a Macintosh. The former would be much easier to transport, and has less system software between the user and the input data. Clearly, the time uncertainties caused by the True Time clock switching between satellites is unacceptable.

Finally, I wish to acknowledge the substantial assistance provided by the seismic and marine crews on board the GECO SEARCHER. Party Chief Torstein Seglem clearly recognized the importance to the client of the piggyback experiment. On many occasions, he rapidly provided operational information that was of critical value to the science party on board the R.V. ENDEAVOR.

APPENDIX 10

Land Recording Stations

Land Experiment

An important component of the EDGE Chesapeake Bay Seismic Experiment was the deployment of land seismometers to record sound energy generated by the GECO SEARCHER's airgun array. The inclusion of onshore seismometers increased the aperture of the wide-angle 'piggybacks' to over 400 km and will help delineate the structure of the rifted continental crust well inboard of the MCS and OBH/OBS data sets.

The land experiment was carried out by groups from the University of Wyoming (Scott Smithson, PI) and University of Georgia (Rob Hawman, PI) (see table). Sixteen PASSCAL REFTEK instruments were deployed at 10 stations by the Wyoming crew and twenty EDA instruments were deployed at one station by the Georgia crew (see table). Shots from Lines 801 and 802 were recorded. Communication between the onshore and offshore teams was maintained by daily INMARSAT or ATS phone calls between the ENDEAVOR and Wyoming crews; the efficiency of these systems and the use of a cellular phone by the Wyoming crew made it possible to keep the land crews well apprised of the status of the shooting.

Table 1: Location of Land Seismometers

Station No.	Latitude	Longitude	Elevation	Instrument	Crew
1	36°40'33"N	75°54'59"W	20 ft.	REFTEK	U. Wyoming
3	36°42'43.8"	75°55'53"	20 ft.	REFTEK	U. Wyoming
4	36°34'27.1"	76°09'25"	10 ft.	REFTEK	U. Wyoming
6	36°47'52"	76°44'55"	50 ft.	REFTEK	U. Wyoming
7	36°53'45.7"	76°54'50.3"	20 ft.	REFTEK	U. Wyoming
8	36°51'59"	76°56'15.3"	35 ft.	REFTEK	U. Wyoming
9	36°59'4.4"	77°13'52"	68	REFTEK	U. Wyoming
10	37°04'58"	77°13'52"	125	REFTEK	U. Wyoming
11	37°12'25.5"	77°37'15.3"	135	REFTEK	U. Wyoming
16	37°19'13.4"	77°31'40.3"	150	REFTEK	U. Wyoming
G-1	36°35'07"	76°09'25"	10	EDA	U. Georgia

Table 2: Land Experiment Field Crew

University of Wyoming:	Chris Humphries Allan Tanner Rick Blenkner
University of Georgia	Rob Hawman Jeffrey Clippard

nted: Sun Sep 16 1990

```

090 ASM X, SUBB #2
005 ASM X, ANDB #6
020 ASM X, CLRA
030 ASM X, ADDD #H40B8
040 ASM X, XGDX
050 ASM X, LDX &H00,X
060 ASM X, LDAA 3,X
070 ASM X, LDAB &H113
080 ASM X, MUL
090 ASM X, STAB &H113
100 ASM X, STAA &H125
110 ASM X, LDAA 3,X
120 ASM X, LDAB &H112
130 ASM X, MUL
140 ASM X, ADDB &H125
150 ASM X, STAB &H112
179 REM - save current memory pointer for adloop
180 ASM X, LDD &H121
190 ASM X, STD &H7190
200 ASM X, LDD &H123
210 ASM X, STD &H7192
220 ASM X, LDAB &H718F
244 REM - look for next valid channel by loading @() for channel
245 E=X
240 ASM X, CLRA
240 ASM X, ADDD #H40B8
250 ASM X, XGDX
260 ASM X, LDX &H00,X
270 ASM X, LDAA &H03,X
289 REM - if @(41),@(42),@(43), or @(44) = 0 then skip channel
290 ASM X, BNE A
300 ASM X, LDAB &H718F
310 ASM X, ADDB #2
320 ASM X, ANDB #6
330 ASM X, STAB &H718F
339 REM - loop until a valid channel is found
340 ASM X, BRA E
350 A=X:ASM X, RTI
355 REM *** HIGH GAIN CHANNEL ***
358 B=X
360 REM *** START OF OBH MOD ***
362 ASM X, LDAB &H718F: REM 3 BYTES
363 ASM X, SUBB #3: REM 2
364 ASM X, ANDB #7: REM 2
365 ASM X, CLRA: REM 1
366 ASM X, ADDD #H40B8: REM 3
367 ASM X, XGDX: REM 1
368 ASM X, LDX &H00,X: REM 2
369 ASM X, LDAA &H03,X: REM 2
370 ASM X, SUBA #1: REM 2
371 ASM X, BEQ A: REM 2 - TOTAL = 20
372 REM *** END OF OBH MOD ***
375 ASM X, LDD &H7196
380 ASM X, BPL C
390 ASM X, COMA
400 ASM X, COMB
410 ASM X, ADDD #1
420 C=X

```

```
30630 ASM X, SUBD &H717A
30640 ASM X, BCC D
30649 REM - right justify the data
30650 ASM X, LDD &H7196
30660 ASM X, ASRA
30670 ASM X, RORB
30680 ASM X, ASRA
30690 ASM X, RORB
30700 ASM X, ASRA
30710 ASM X, RORB
30720 ASM X, ASRA
30730 ASM X, RORB
30740 ASM X, STD &H112
30742 REM *** GET MEMORY POINTER AND STORE THE DATA ***
30745 D=X
30749 REM - load LSB of datafile pointer from @(34) and save in index reg.
30750 ASM X, LDD &H0123
30760 ASM X, ANDA #&H7F
30770 ASM X, ADDD #&H4000
30780 ASM X, XGDX
30789 REM - load MSB of datafile pointer from @(34) and adjust for bank
30790 ASM X, LDD &H0122
30800 ASM X, ASLD
30810 ASM X, INCA
30819 REM - save the data in memory
30820 ASM X, JSR &H114
30829 REM - update memory pointer from @(34)
30830 ASM X, LDD &H7190
30840 ASM X, STD &H121
30850 ASM X, LDD &H7192
30860 ASM X, STD &H123
30870 ASM X, RTI
30880 X = &H40B8
30882 REM *** STORAGE PARAMETERS ***
30885 ASM X, DW &H7174
30890 ASM X, DW &H7170
30895 ASM X, DW &H716C
30900 ASM X, DW &H7168
31000 REM *** STORE THE DATA ***
31010 X=&H114
31019 REM - update new bank value
31020 ASM X, ORAA &H17
31030 ASM X, STAA &H17
31032 REM - load data and save it at pointer in index reg.
31035 ASM X, LDD &H112
31040 ASM X, STD &H00,X
31049 REM - restore bank value back to bank 0
31050 ASM X, AIM &HF8,&H17
31060 ASM X, RTS
31100 REM *** STORAGE PARAMETR ***
31125 ASM &H121,DW @(34)/65536,@(34)%65536
31130 RETURN
```

APPENDIX 11

EG&G Release/Transponder System R. Handy

The EG&G release units were all wire tested to 1000 meters in 2000 meters of water. All units were enabled, disabled, and released.

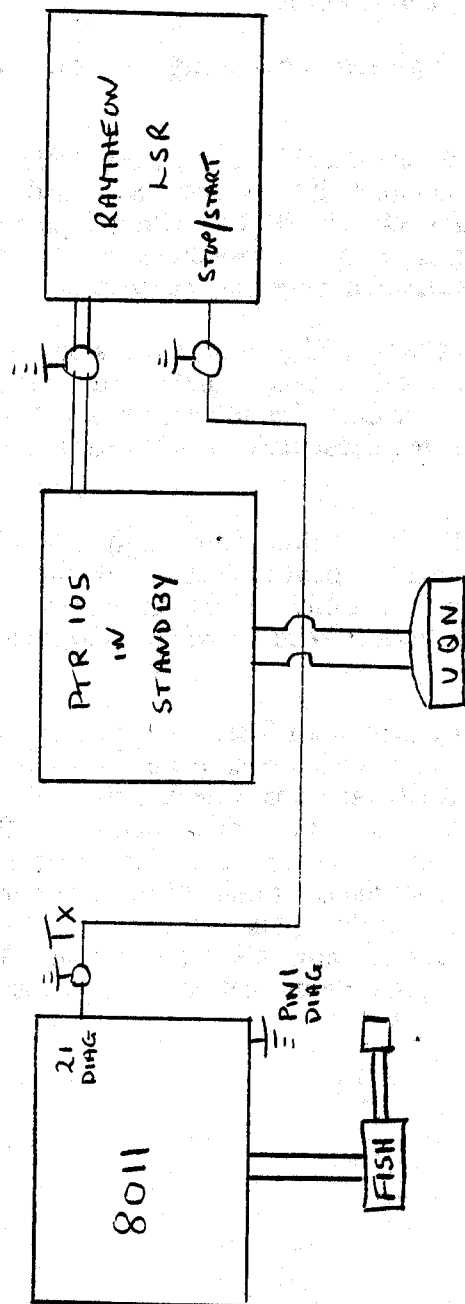
Each OBH frame had one high frequency reply and one low frequency reply unit installed.

On deployment of OBH-21 we are not able to give release #13652, a disable command. At the time we were going through the hull transducer. Switched to the towed fish but still can't shut unit off. Replaced our deck unit (8011A) with the spare deck unit (8011). After raising the threshold and putting in a range gate we are able to talk to release and disable it. The reply frequency of this unit was in a range that was very noisy.

On deployment of OBH-20 after enabling both releases on deck, find we can't disable release #14738. It stays in a 2-second ping mode and we can't get a disable command into it. Have to take this release out of OBH frame and replace it with a spare unit. After placing release #14738 in the spare release racks on deck for a few hours, it quieted down enough to disable it.

On deployment of OBH-17, found that strobe light SN 18071 would not work. Checked batteries and found a small amount of water inside the case. After cleaning unit put new batteries in and it works. Think this unit may have been used in Buzzards Bay and the end cap was not screwed in tight. Wire tested to 1000 meters and found no water leaks.

When we had finished deployment of all OBH frames we did a wire test of the release that would not shut off on deck and one other release that did not release completely on first wire test. We used the towed fish and spare deck unit (8011). After enabling and disabling both units we switched back to our own deck unit (8011A) and enabled and disabled both units. We then sent a release command to both units. This deck unit (8011A) is working fine now. Shut the deck unit off for about one-half hour. When we turned this unit back on we were unable to talk to the releases that are on the wire. Shut deck unit off and back on again and can now talk to the releases. Think that this deck unit has some switch or powering up problems that at times keeps us from talking to the releases.



EG&G 8011 CONFIGURATION

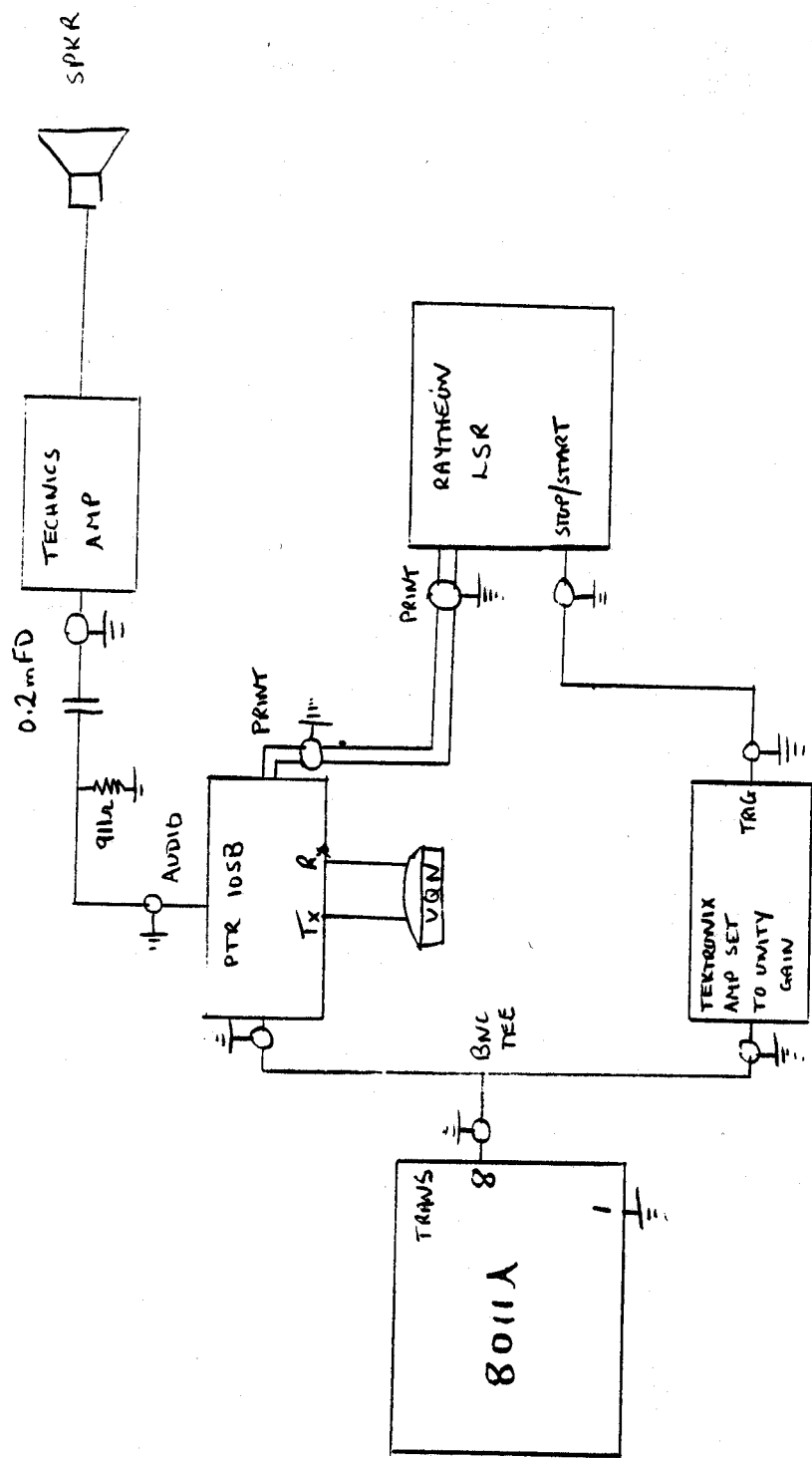


FIG 6 8011A CONFIGURATION

APPENDIX 12

Communications

It is obvious that good communications is critical to an operation of this type that requires almost continuous coordination.

- **INMARSAT:** Throughout we depended upon INMARSAT as the absolute reliable system for both inter-ship and ship-to-shore calls. INMARSAT was critical to the success of our operations: it allowed contact to be made without establishing a previous schedule so that unexpected events could be handled reasonably. However it is simply too expensive to be used for ongoing communications. During the first two days of our cruise we used it heavily to establish solid contact with SEARCHER and with the land crew and spent ~\$500. This allowed us to establish good working frequencies with the SEARCHER on SSB and to set up a schedule via ATS for calling the land crew on one of their cellular phones.
- **Single Side Band Radio:** Approximately 75% of all inter-ship communications took place on SSB at 4125 MHz. This worked extremely well, typically making contact at 4-8 hour intervals to determine status. On 13th September, SEARCHER's SSB transmitter broke down and on one previous occasion contact was lost due to a receiver failure on SEARCHER and a quick INMARSAT call was required to re-establish communications.
- **VHF:** By far the simplest and highest quality system but beyond 30-40nm contact was intermittent. Also in heavy traffic regions SEARCHER's bridge sometimes was working two VHF channels simultaneously so in order not to interfere SSB was preferred.
- **ATS:** The quality of this was surprisingly good and without it communication with the land crew would have broken our budget with INMARSAT costs. ATS allowed daily ~10 min. calls to Chris Humphries, generally on his cellular phone, that were crucial to keeping them informed of the status and progress of the shooting program. Humphries in turn kept in contact with Bob Hawman.

No single system could have satisfied our communication requirements adequately. All four - INMARSAT, SSB, VHF and ATS - played an important and separate role.

APPENDIX 13

Data List

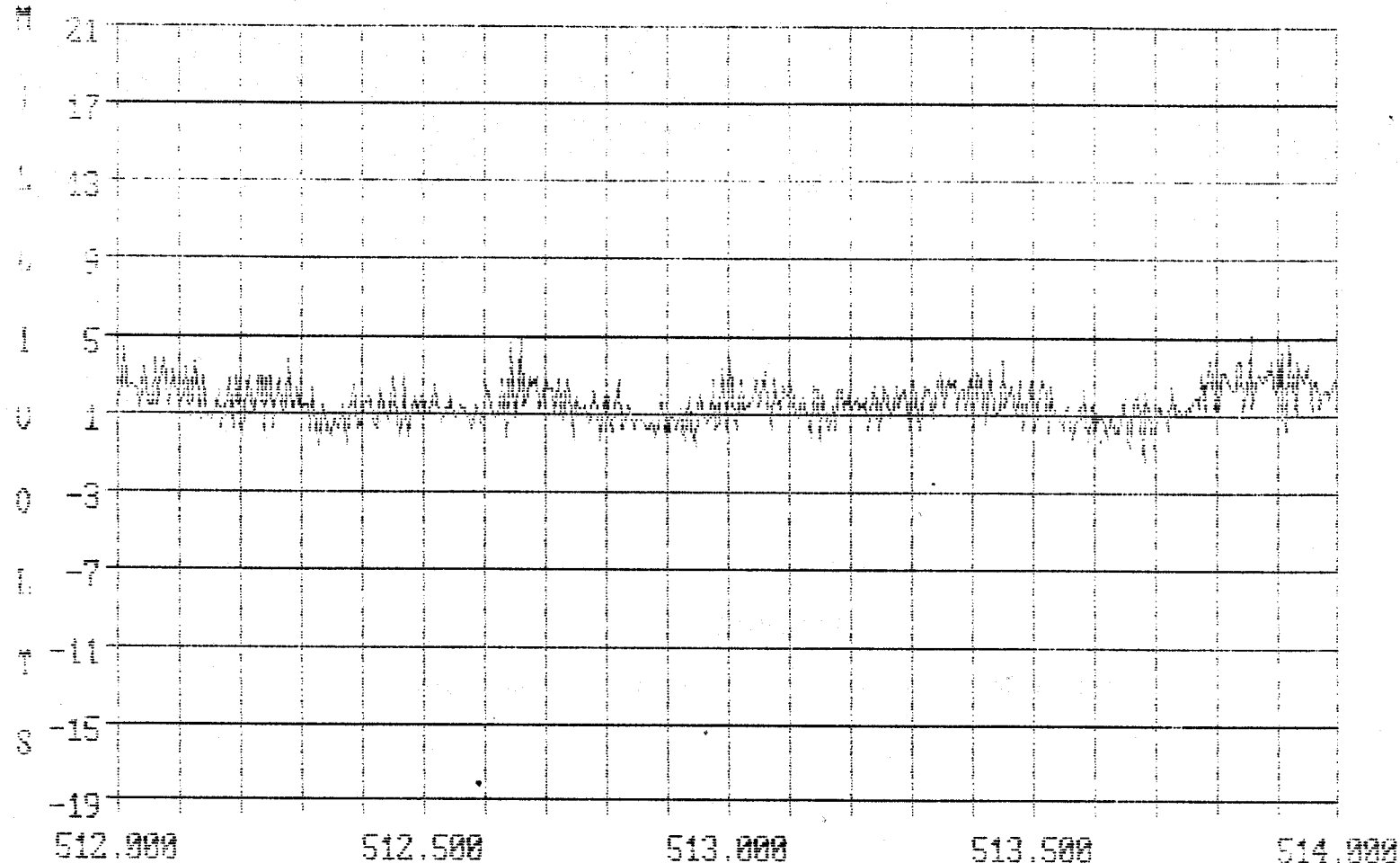
- 1 Envelope CHES Weathermaps
- 7 USGS OBS Receiver Books
- 8 WHOI OBH Receiver Books
- 1 Binder of six CHES02 OBH Track Header Listings
- 1 Main Lab Logbook
- 1 Magnetic Tape of Navigation Data
 - Trimble GPS Latitude and Longitude
 - Loran 800 Latitude and Longitude
 - Loran 7000 Latitude and Longitude
- 1 Double-Sided High Density Floppy Disk of USGS OBS Deployment Logs and Track Header Listings
- 3 SONY EXABYTE cartridges of USGS OBS Data
 - 1) CHEZ01Z.DAT
AST823.DAT
 - 2) CHES02A1.D1,*.D2,*.D3
CHES02A2.D1,*.D2,*.D3
CHES02A8.D1,*.D2,*.D3
 - 3) CHES02C4.D1,*.D2,*.03
CHES02C3.D1,*.D2,*.03
CHES02C9.D1,*.D2,*.03
- 2 Rolls echo sounder transponder records of instrument deployments and recoveries; spot depth checks.
- 1 NOAA LORAN Navigation Chart #12200 marked with shot lines and instrument locations.
- 6 OBH Engineering Notebooks
- 1 CHES Clock Notebook
- 2 EXABYTE data cartridges of WHOI/SEISMICS OBH data files
 - 1) CHESAPEAKE 18 files - difference is addition of file CONFIG. SYS
 - 2) CHESAPEAKE2 17 files
- Copies of Ships Logs R/V ENDEAVOR Cruise #217
- File of Airgun Shot Instants Recorded on GECO SEARCHER
- 16 EG&G Transponder Logbooks

APPENDIX 14

Ambient Noise Samples from the Ocean Bottom Hydrophones

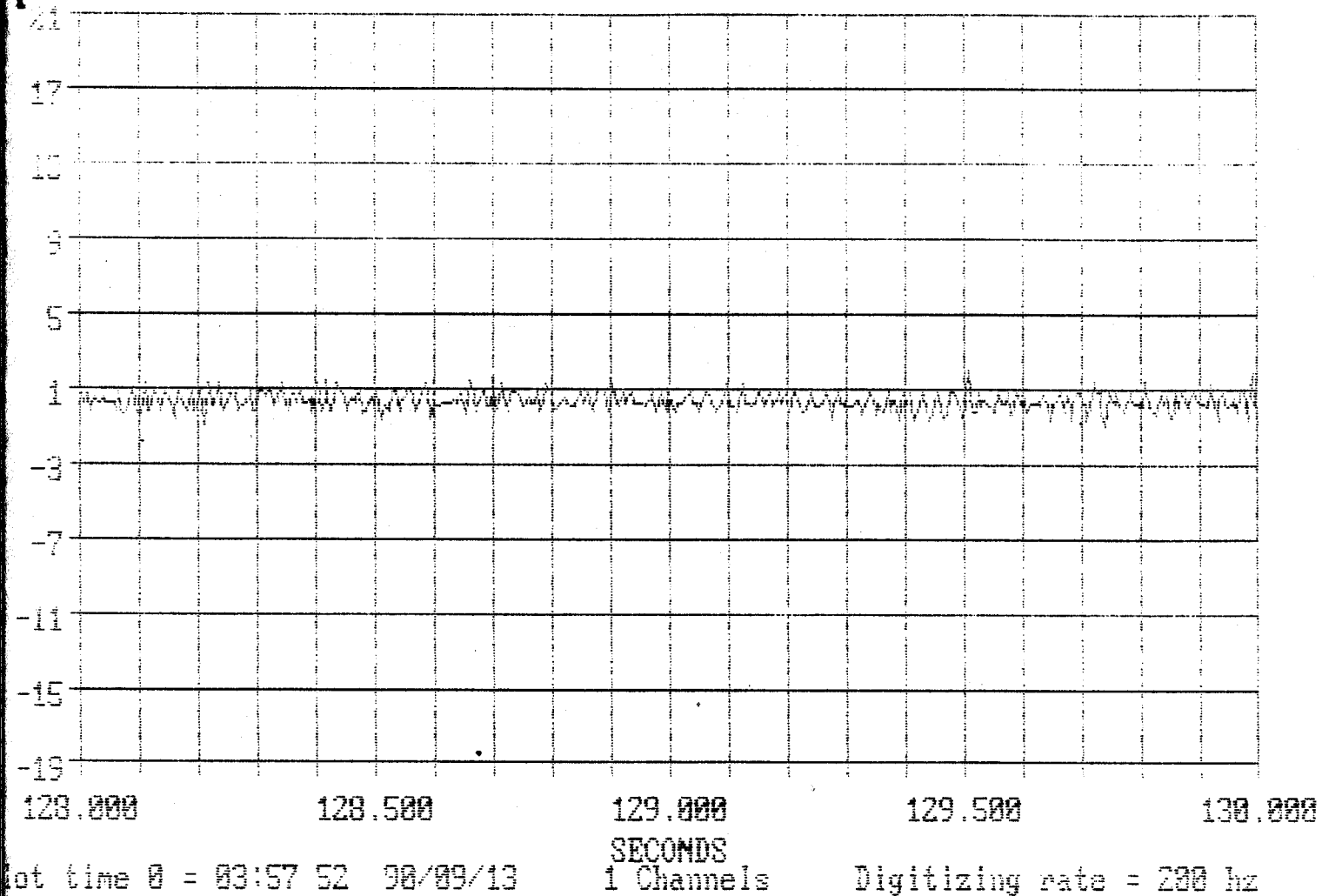
CH1

FILE = CHE38216.D2 - TRACK DUMP # 54



Plot time 0 = 03:51 28 98/09/13 1 Channels Digitizing rate = 200 hz

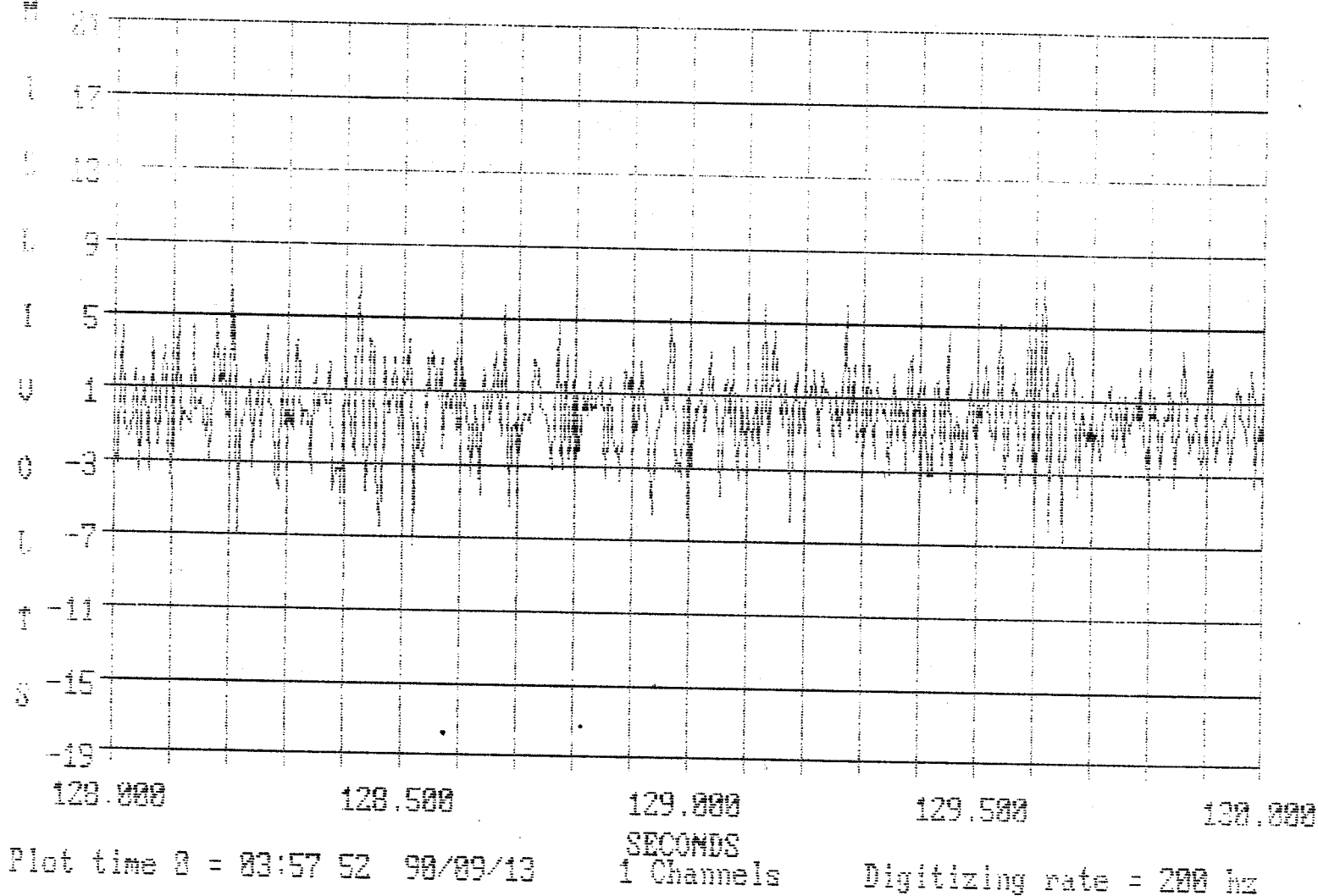
A two second long sample of ambient noise for OBH 16. 0.88 millivolts = 1 μ bar.



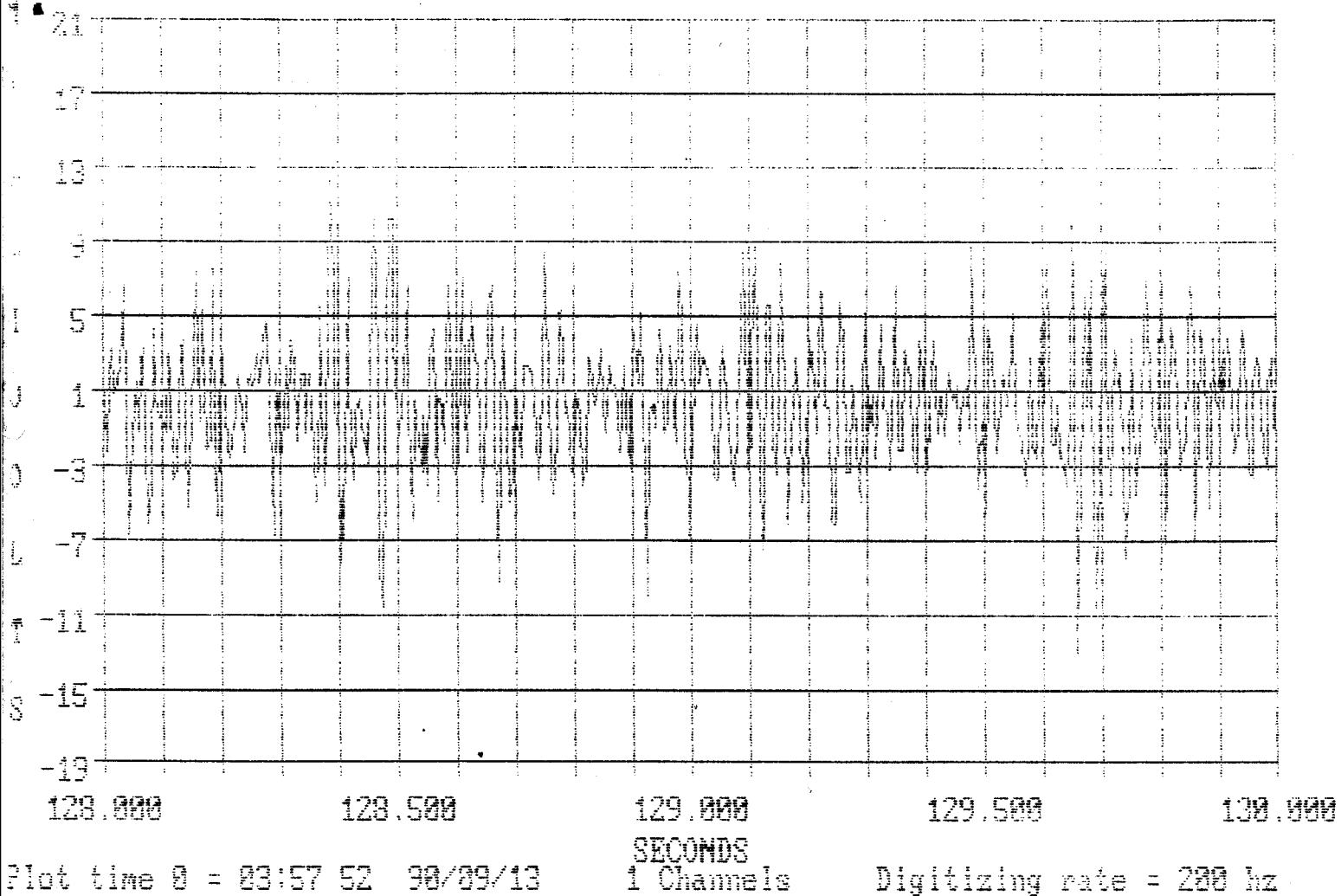
A two second long sample of ambient noise for OBH 17. 0.88 millivolts = 1 μ bar.

CH1

FILE = CHES0219.D1 - TRACK DUMP # 7



A two second long sample of ambient noise for OBH 19. 0.88 millivolts = 1 μ bar.



A two second long sample of ambient noise for OBH 20. 0.88 millivolts = 1 μ bar.

APPENDIX 15

Lessons: Some New, Some Old

- To work effectively with a commercial vessel scheduling flexibility of 2-3 weeks is needed for the instrument deployment ship.
- An experiment coordinator on the commercial seismic vessel is absolutely critical: John Collins on GECO SEARCHER was key to the success of this project. A good communicator with sufficient understanding of the operational complexities to make good judgement calls and whose first allegiance is to the 'piggyback' program is essential.
- The 6-7 day continuous recording capacity of the OBH's was ideal: this provided the flexibility to deploy well in advance of shooting without fear of data loss. The 36 hour capability of the OBS is satisfactory for all but the largest lines, but requires care in choosing turn-on times. For four component measurements a reduction of sampling rate to 100 Hz (with appropriately high quality anti-aliasing filters) would help this problem, as would the operation of perhaps some of the instruments in a single component (hydrophone or vertical) mode.
- Good communications are critical. If GECO SEARCHER's SSB radio had broken down a day or two earlier than it did we would have bankrupted the project with INMARSAT calls. At least 2-3 independent systems are needed to assure reliability.
- The deployment and operation of ocean bottom instruments is, and always will be, a complex operation. When the need to coordinate timing with a second vessel is added, the difficulties are substantially increased. Thus to carry out an operation of this kind in a reasonable manner with an acceptable chance of achieving success a full capability UNOLS-type vessel is needed. The space, facilities and support equipment available on such a vessel are essential. ENDEAVOR was excellent.
- The Novatech VHF radio beacons combined with the SIMRAD Taiyo automatic direction finder were superb. Bearings good to $\sim 5^\circ$ were available seconds after an instrument surfaced.
- Recovery of instruments with acoustic transponders is not a reasonable activity unless the returns can be displayed on a graphics recorder, thus permitting coherency of signals in high noise environments to be recognized and facilitating the recognition of changes in slope.
- The new EG&G system is excellent. The towed fish transducer worked superbly. We need another one as a backup.
- Time remains a problem (see Appendix 6). True Time satellite clocks are not the total solution. Future operations will require better systems.